EYESIGHT AND HOW TO CARE FOR IT

HARLAN

This is a contribution
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AND

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BY

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EYESIGHT,

AND

HOW TO CARE FOR IT.

CHAPTER I.

INTRODUCTION.

THE subject selected for this number of the series is a wide one. Involving, as it does, the sciences of anatomy, physiology, and optics, it has enlisted earnest and distinguished workers from all, and has accumulated a literature of its own which an ordinary lifetime is hardly long enough to master. It is not without a certain sense of absurdity in the undertaking, that an attempt is made to crowd such a subject into so small a space; but it will, of course, be understood that nothing more is intended than a superficial and hasty glance at its general outlines. The object will be to place before the reader such elementary knowledge as is necessary to enable him to understand the conditions under which the eyes must

do their work; and to place this knowledge within the reach of all, the explanations will be made as simple as possible, and the use of "technical language," that lion so much dreaded in the path of the general reader, will be carefully avoided.

That an intelligent care of the eyesight requires some knowledge of the structure and functions of the organ of vision, is a proposition too plain to admit of argument. Even aside from utilitarian considerations, indeed, one would suppose that a subject so important and so full of intrinsic interest would have irresistible attractions for every cultivated and inquiring mind; but the experience of the ophthalmic surgeon, in his daily practice, forces upon him the conviction that this is far from being the case, and that for most people, outside of the medical profession, the anatomy and physiology of the eye, and the simplest laws of optics that apply to it, are practically a sealed book.

Nor has this much abused organ had fairer play in practical use than in theoretical knowledge, for many who would give to tired limbs or back the needed rest, or nurse a lame leg with the most tender care, will goad on their willing but disabled or overstrained eyes in the most reckless way.

Whatever practical hints may be given will have reference to prevention rather than cure. The former is within the province of common sense, guided by

such general knowledge as every person of good education should have; while the first requisite for the latter is the ability to determine what is to be cured, in other words, the power of forming a correct diagnosis, which can come only by special study and careful training. The lawyers have a saying that "the man who pleads his own case has a fool for a client;" and many and sad results are met with in proof of the fact that the man who undertakes to "doctor" his own eyes has a patient who is far from wise, and who runs a great risk of being very unfortunate; but nowhere is an ounce of prevention more certainly worth many pounds of cure, and all may avoid subjecting the organ upon which our labors and our pleasures so essentially depend to unnecessary peril by carelessness, imprudence, or want of knowledge.

In an effort merely to popularize established facts and accepted theories which have become the common property of scientific men, it will, of course, be understood that no originality is claimed, and it will not be necessary to weary the reader with reference to authorities.

CHAPTER II.

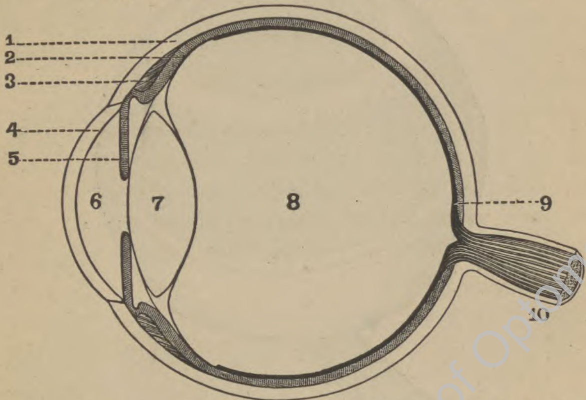
THE ANATOMY OF THE EYE.

IN the small space occupied by the eye and its appendages, all the anatomical elements of the body are represented, arranged with a delicate adjustment to each other, and an exquisite adaptation of every part to the great object of the whole, that render this little organ one of the greatest wonders in Nature. Of course, no attempt can be made here to enter into nice details, but only to give a general idea of the anatomical structure.

The eyeball is nearly spherical in form and about an inch in diameter. For convenience of description, it is sometimes spoken of as consisting of three *membranes*, or coats, and three *humors*. The external or fibrous coat is a firm, tough membrane, having almost the resistance of leather, and is about one twenty-fourth of an inch thick. It maintains the form of the ball, furnishes attachments to the external muscles that move it, and protects its delicate contents. The *sclerotic* (Fig. I., 1), which includes the posterior four-fifths of this coat, is opaque, and forms what is known as the "white

of the eye;" the anterior one-fifth, the *cornea* (Fig. I., 4) is transparent, and is joined to the sclerotic somewhat as a watch-glass is set in its case. On ac-

Fig. I.—Vertical Section of the Eyeball.



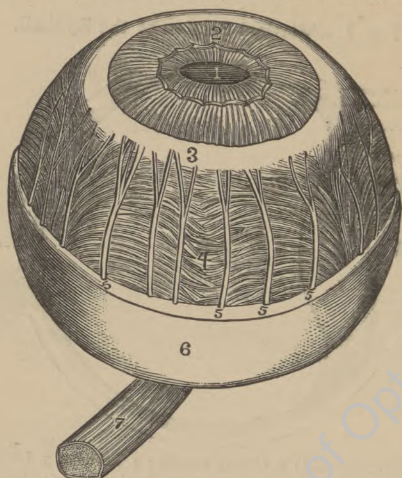
1. Sclerotic; 2. Choroid; 3. Ciliary muscle; 4. Cornea; 5. Iris; 6. Aqueous humor; 7. Lens; 8. Vitreous humor; 9. Retina; 10. Optic nerve.

count of its transparency, the cornea can be best seen by looking at it from the side, or by observing the reflection of a window-sash upon its surface; we usually look directly through it and see only the colored iris behind it.

The next coat, called the vascular because it contains most of the blood-vessels of the eyeball, comprises the choroid and iris. The choroid lies against

the inner surface of the sclerotic, and the iris forms a curtain behind the cornea.

Fig. II.— Iris, Ciliary Muscle, and Choroid.



The Whole of the Cornea and Part of the Sclerotic have been Removed.

1. Pupil; 2. Iris; 3. Ciliary muscle; 4. Choroid; 5. Ciliary nerves; 6. Remainder of Sclerotic; 7. Optic nerve. (*After Gray.*)

The *choroid* (Figs. I., 2, and II., 4) consists principally of a net-work of blood-vessels lined with a layer of flat, dark brown, or nearly black, pigment cells, which also covers the posterior surface of the iris. The use of this dark surface is to absorb the excess of light, which,

by reflection and diffusion, would prevent accurate vision.

The *iris* (Figs. I., 5, and II., 2) forms a curtain stretched across the interior of the eye, behind the cornea, at the margin of which it is attached. It is the iris that gives to the eye its special color, and upon which its beauty, to a great extent, depends. When we speak of a blue, brown, hazel, or black eye, we mean that this is the color of the iris — hence the name of iris, or "rainbow." The original color of the iris is blue, and depends not upon a pigment, or coloring matter, but upon what opticians call an "interference phenomenon," — that is, it is the result of the effect upon each other of waves of light reflected back and forth from the minute irregularities of its surface, — and the permanent hue is formed by the addition of a greater or less amount of dark pigment. The color of the iris is usually in accord with the general coloring of the individual, so that we have every variety of shade, from the black of the negro through the dark brown of the brunette, and the gray or blue of the blonde to the colorless iris of the albino. The eyes of albinos are pink, not from the color of the iris, but from the reflection seen through it, from the red blood in the vessels of the choroid in which also pigment is absent. A good example of this kind of eye may be seen in the white rabbit. The pink eyes, transparent skin,

and snow-white hair of true albinos give them a most peculiar appearance. Their sight is always deficient, and they are painfully sensitive to light, against an excess of which they have not the natural protection.

It is not generally known that the eyes of infants are always blue, and that they do not begin to assume their permanent color until the sixth or eighth week. There is therefore truth, as well as poetry, in the statement that babies look about them "in blue-eyed wonder." The wonder may be left to poets and philosophers, but the blue is always a practical fact. It is not uncommon to see different colors in the eyes of the same person, and even in the same eye half of the iris is sometimes brown and the other half blue.

There is a popular notion that dark eyes are stronger than light ones. There is no truth in this except so far as they are better protected against excessive light; hence, light eyes prevail among northern nations and dark eyes among the races who live in the glare of a tropical sun.

Near the centre of the iris is a round opening, the *pupil* (Fig. II., 1), through which all the light that enters the back part of the eye must pass. Through the action of two sets of muscles in the iris, one circular and the other radiating, the pupil has the property of contracting and dilating, and its function is to regulate the amount of light admitted to the retina. When we pass from a dark room to a brightly lighted one, the pupil contracts, to protect the eye from the irrita-

ting glare of a flood of light; and when we pass into the dark it dilates, to admit as much of the insufficient light as possible. Belladonna applied to the eye, or taken to excess internally, dilates the pupil, and Calabar bean contracts it to a pinhole. Opium also contracts it, and this is the first symptom looked for when opium poisoning is suspected. When we look at a distance, or when the eyes are not directed to any object, as in meditation, the pupils dilate; and this pensive expression is said to be sometimes imitated by the use of belladonna. A light eye is also made to appear dark in this way, and the expression of the face is very much changed. The pupil is much smaller in the old than in the young, and this partially compensates for one of the optical defects incident to age.

The shape of the pupil varies in different animals; in the cat, for instance, it is a long, narrow slit when contracted, and round when dilated.

In the human eye, the pupil appears black; but in the eyes of certain animals it presents, in obscure light, a bright glare, which, even when seen in the cat, sometimes makes superstitious or nervous people uncomfortable, and must add not a little to the terrors of a lion or tiger ready to spring upon his prey. Before the present century, this was thought to be a kind of phosphorescent emanation from the retina, and to glitter more brightly when the animal was excited; but it is now known to be merely a reflection

from a bright patch of metallic lustre, found upon the choroid of these animals, called the tapetum lucidum.

At the junction of the iris and choroid is found a narrow band of delicate muscular fibres, called the *ciliary muscle*, (Figs. I., 3, and II., 3.) This little muscle has a very interesting and important function, which will be referred to later.

The *retina*, the third or nervous membrane, (Fig. I., 9) is the most important of all; indeed, all the other structures of the eye may be considered subservient to this one, for on it are formed the images of external objects, by means of which we are said to *see* them. It is a very complicated and extremely delicate structure, offering endless difficulties to the investigator; and, though an immense amount of labor has been expended upon it by many masters in science, its minute anatomy can hardly yet be considered settled. Though its greatest thickness does not exceed one one-hundred-and-twentieth of an inch, microscopists have described some eight or ten different layers, only two of which it will be necessary, for our present purpose, to refer to. The external is sometimes spoken of as the percipient layer, because it receives the images of objects and produces a sensation which is conveyed to the brain, telegraphed, as it were, by the fibres of the internal or conductive layer. This external layer, called Jacob's membrane, is shown by the microscope to consist of minute

columns arranged side by side perpendicular to the choroid, while the internal, or nerve-fibre layer, is composed of delicate nerve-fibrils forming a surface parallel to the choroid. A number of the little columns connect with each nerve-fibril, and the fibrils collect into a bundle which passes through the sclerotic at the back of the eye and, receiving a strong sheath, forms the optic nerve.

The *optic nerve* (Figs. I., 10, and II., 7) passes from the eye to the brain. In this way all the columns of the external layer of the retina are brought into direct communication with the brain, and may be almost said to feel the retinal image, just as the papillæ of touch in our fingers feel any object with which they are brought in contact.

As each kind of nerve responds to a special sensation, and has no concern with any other, the optic nerve can convey no other impression than that of light, and can no more conduct a sensation of pain than a nerve of ordinary sensation can see; hence, when irritated, as by galvanism, it responds by a flash of light. When the retina is irritated by the concussion of a violent blow, the flashes of light that result have given rise to the expression of "seeing stars." Disease of the retina or optic nerve frequently destroys sight entirely without exciting the slightest pain.

The three *humors* are the aqueous, crystalline, and vitreous.

The *vitreous humor* (Fig. I.,8) occupies four-fifths of the interior of the ball. It is colorless and transparent, and has rather less consistence than gelatine jelly. It is admirably adapted to maintain the form of the eyeball and give to the retina, which is spread upon its outer surface, the necessary support, while, at the same time, it yields sufficiently to protect this delicate structure from injury by jarring or external pressure. The eye is a wonderful example of skilful packing, combining firmness, elasticity, compactness, mobility and safety in a degree of perfection that can never be approached by art, and is perhaps scarcely equalled elsewhere in Nature.

The *crystalline humor*, or lens (Fig. I., 7), is firmer than the vitreous, but not solid, and is shaped much like a double convex lens or ordinary "magnifying glass." Its form is maintained by a thin, transparent, elastic capsule, and in young persons its consistence is such as to allow its convexity to be readily altered. It grows denser by age, which is the cause of "old-sight;" when it is no longer possible to increase the convexity of the lens, a convex spectacle glass must be used for near vision. The lens rests in a cup-shaped cavity in front of the vitreous, and is therefore just behind the iris, with its centre opposite the pupil.

The *aqueous humor* (Fig I., 6) is nearly pure water, and is contained in the space between the cornea and lens.

The eyeball is imbedded in a soft cushion of oily

fat, which supports and protects it, and, at the same time, allows it to move in all directions as freely as if it floated in water.

The *orbit*, in which the ball is lodged, is a hollow cone of bone with the base directed forwards and outwards. The external edge of the orbit extends much less forwards than the internal, and the axes of the two orbits, if followed back, would meet at an angle of 45°; an arrangement which permits the widest lateral range of vision consistent with the power of directing both eyes at the same time to a near object — that is, the faculty of binocular vision. The position of the orbits varies much in different animals; in some, whose chance in the struggle for existence depends more on flight than on defence, the eyes are placed so entirely at the side of the head that they can see almost as well behind them as in front. They have a wide range of vision, but have not the ability to direct both eyes to the same object. This arrangement is very marked in the giraffe, whose eyes we can see almost as well when we stand behind him as we can in front. The edges of the orbit are comparatively dense and strong, particularly the upper one, which overhangs the eye, and is capable of shielding it from a very powerful blow; as is frequently attested by what is known as a "black eye," when the surrounding tissues are swollen and inflamed and filled with blood, while the eye peeps through them quite unharmed.

When the eyeball itself is injured by the fist, it is always by a blow aimed from beneath.

The case is different with the deeper part of the orbit, the roof of which is formed of a plate of bone scarcely thicker than parchment. The front portion of the brain rests upon this bone, and has frequently been fatally wounded by injuries involving it. Duelists have sometimes selected the roof of the orbit as a vulnerable spot for a sword-thrust, and Henry II., of France, was accidentally killed at a tournament by a lance-point that pierced his brain through this fragile bone.

The *eyebrows* are formed of muscle and thick skin, covered with stiff hairs, and resting on a bony ridge above the edge of the orbit. The hairs are arranged somewhat like the straw on a thatched roof, and shed the perspiration that trickles down the forehead. Another useful purpose is shown by the way in which they are instantly drawn down when we are suddenly exposed to a dazzling light. They have æsthetic functions, too, as powerful organs of expression. A frown is produced by wrinkling and depressing the brows, while by elevating them we can express incredulity, surprise, or contempt almost as plainly as by words. The word *supercilious* is derived from supercilium, the Latin term for eyebrow. The eyebrows may be considered almost distinctive in man; the seal has a few stiff hairs, and in some birds, as the

falcon, they are represented by an arrangement of the feathers above the eye; but even our supposed immediate progenitors, the monkeys, cannot lay claim to them.

The *eyelid* is covered with thin, loose skin and lined with smooth and delicate mucous membrane, and between these is a plate of cartilage, to give it shape and firmness, and the muscles that move it. The upper lid, which is much the larger, is very movable, while the lower one is almost stationary. It results, from this disproportion in size, that when the eye is closed, the pupil is completely covered by the upper lid, and is much better protected than it would be if opposite to the fissure between them. An additional protection is afforded during sleep, or when the eye is threatened with violence, by a rolling upward of the ball.

The skin of the lids contains no fat; a fortunate provision, for if fat increased there as it sometimes does in the rest of the body, the eye would be mechanically closed. This mechanical blindness often results from swelling of the lids by injury or disease. Patients with erysipelas of the face are frequently much alarmed to find themselves completely blind; but it is consoling to know that the disease very rarely extends to the eye itself. The thin and delicate skin of the lower lid, loosely attached to the tissues beneath, furnishes valuable indications of the state of the circulation.

A puffiness and a dark shade under the eye show a sluggishness in the flow of the blood, and a more decided swelling is one of the first symptoms of some kinds of dropsy. The lids lie gently upon the eye, and are maintained in accurate contact with it by atmospheric pressure. The two surfaces move against each other with perfect freedom, and with an entire unconsciousness of friction, which the presence of the minutest particle of dust, or even a congestion of the blood-vessels, will at once disturb. This freedom from friction depends not only upon the smoothness of the surfaces and their exquisite adaptation to each other, but they are lubricated by a secretion of mucus from the conjunctiva, and moistened by a constant flow of tears. The polish and transparency of the cornea are maintained by frequent unconscious winking, which keeps its surface moist and free from dust. When the muscle that closes the lids is paralyzed, the cornea soon becomes hazy and dim, and blindness sometimes results. A number of small glands that open near the roots of the lashes keep the edges of the lids greased with an oily secretion which impedes the overflow of tears. This effect may be seen by greasing the edges of a cup, and then filling it with water, when it will be found that the surface of the water can be raised to a higher level than the edges of the cup. The lashes have a decided curve, whose convexity is downward

in the upper set and upward in the lower, and when the lids are partially closed, they interlace in such a way as to form a screen, which, without excluding vision, serves as an admirable protection against wind and dust or excessive light. As their bulbs are freely supplied with nerves, they are delicately sensitive to the slightest touch, and act as "feelers" to warn the eye of the approach of any small object, as an insect, in the dark, or when the vision is not on guard. They differ from other hairs, in being thickest in the middle and tapering towards each end, and undergo a constant renewal; each one reaches maturity in about five months, and then drops out, and is succeeded by a fresh one. When this process is interfered with by inflammation of the edge of the lid, the new lashes sometimes take a wrong direction, and turn their points against the eyeball. They are then popularly called "wild hairs," and not only cause intense discomfort, but may inflict serious injury. It is quite a common mistake to attribute an irritation from some other cause to "wild hairs," and many persons pull out their lashes with great perseverance and patience, but without the slightest provocation.

The mucous membrane of the eye is continuous with the skin at the margin of the lids. After lining the inner surface of the lids, it passes over to the ball, forming a loose fold, which is the only direct con-

nection between them; hence its name, *conjunctiva.* It covers the front part of the sclerotic, the whole of the visible portion, and, lining the walls of the tear-duct, becomes continuous with the mucous membrane of the nose and throat, and, therefore, usually takes a part in a "cold in the head," or influenza. It is ordinarily nearly white, with, perhaps, a few of the larger blood-vessels seen winding through it, but is very easily congested by local injury, or inflammation, or by general disturbances of the circulation, particularly of the head, as in the case of the "bloodshot" eye that tells of a debauch. The characteristic yellow tinge of the eye in jaundice is due to the coloring matter of bile deposited in the conjunctiva.

The opening between the lids is called the *commissure,* and the apparent size of the eye depends chiefly upon the width of this space. The actual size of the eye varies comparatively little in different individuals, but some eyes appear much larger than others, because the lids are more widely opened. When an inflamed eye is kept constantly partially closed from an excessive sensitiveness to light, much anxiety is often caused by the conviction that it is becoming smaller.

The almond shape of the Eastern beauty's eye depends upon the length of the fissure between the lids, and its effect is sometimes imitated by prolonging the shadow at the outer angle of the commissure with

a few touches of the "cosmetic pencil." In the Chinese, the outer angle of the commissure is much higher than the inner, giving the cleft an obliquity upwards and outwards. (Fig. III.) This has a very marked effect upon the expression of the face, which, at least to Caucasian taste, is always sinister; the pictures of Mephistopheles owe much of their devilish cast to the twitching upwards of the external angles of the lids. It is a curious illustration of the natural prejudice in favor of our own peculiarities, that in Chinese caricatures of the "Melican man" the outer angles of the eyelids are absurdly drawn downwards.

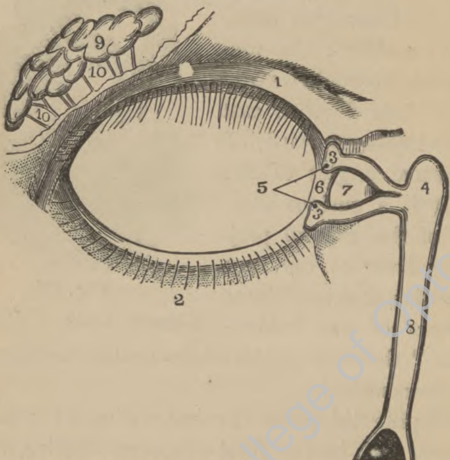
Fig. III.
Chinese Lady. (*Whalley.*)

A drooping lid gives the impression of weakness or fatigue, and, in the final stages of wasting fevers, the half-closed eye, concealing the cornea and iris and exposing only the white sclerotic, has a painfully ghastly effect, and is a most discouraging symptom.

The *lachrymal apparatus* (Fig. IV.) consists of the gland for secreting tears and the passages for draining them off. The gland, 9, is lodged in a depression

in the roof of the orbit above and to the outer side of the eyeball, and its secretion is poured upon the ball through a number of small ducts, 10, which open through the free fold of the conjunctiva.

Fig. IV. — Lachrymal Apparatus.



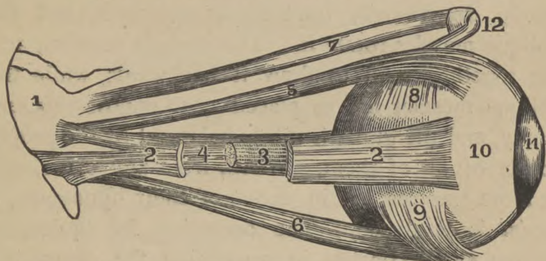
(The skin of the lids has been removed.)

1 and 2. Cartilages of lids. 3. Lachrymal canals. 4. Lachrymal sac. 5. Lachrymal puncta, or entrance to canals. 7. Lachrymal lake. 8. Nasal duct. 9. Lachrymal gland. 10. Lachrymal ducts. (*Gray.*)

After passing over the surface of the eye, the tears are taken up by passages, which commence near its inner angle, 3, and conducted into the nose.

On the margin of each lid at the inner angle may be noticed a slight elevation, called the papilla, and on its summit a pinhole opening, called the punctum.

Fig. V.—External Muscles of the Eyeball.



1. Piece of orbital bone. 2. External straight muscle, with piece cut out. 3. Optic nerve. 4. Internal straight muscle. 5. Upper straight muscle. 6. Lower straight muscle. 7. Upper oblique muscle, attached to ball at 8. 9. Lower oblique muscle. 10. Sclerotic. 11. Cornea. 12. Pulley for tendon of upper oblique. (*Gray.*)

These openings are the mouths of the lachrymal canals, two small tubes which pass nearly horizontally towards the nose and empty into the nasal duct, 8. The ordinary flow of tears is thus drained into the nostril, and they overflow the lids only when the gland is excited to excessive secretion by local irritation of the eye or by mental emotion. A slightly increased secretion may still be carried into the nostril and excite the "sniffing" which is usually the first stage of a "good cry." Infants do not shed

tears before the third or fourth month, and the elephant is the only one of the lower animals accused of this human weakness.

The eyeball is moved in various directions by six muscles, (Fig. V.) The straight muscles turn it upwards, downwards, inwards, or outwards, and the oblique muscles rotate it. The straight muscles, acting together, tend to draw it backwards, while the oblique muscles are so placed as to oppose this tendency, and the globe is nicely balanced by the proper action of all of them. When, from any cause, one or more muscles act in excess of their opponents, a *squint* is produced. The operation for squint, or "cross eye," consists in weakening the overacting muscle by cutting it.

CHAPTER III.

THE PHYSIOLOGY OF VISION.

THE act of seeing was involved in the mystery with which all vital functions were in former times invested, until the great astronomer, Kepler, first recognized the fact that the eye is a camera, and, as such, is subject to the same physical laws as any other optical instrument. Images of external objects are formed by the eye exactly as they are formed by a photographer's apparatus; in the latter they fall upon a chemically sensitive plate, and are made permanent by the chemical changes induced by light; in the eye they fall upon the nervously sensitive retina, and their impression is conveyed to the brain by the fibres of the optic nerve.

To understand anything of the physiology of vision, it is necessary to have a general idea of the way in which images of objects are formed by refracting surfaces. Light emitted from luminous bodies, or reflected from the surface of non-luminous bodies, moves in straight lines, and the smallest conceivable line of light is called a *ray*. Rays of light, then, are

merely suppositious lines used by opticians to enable them to bring the effects of an intangible force within the range of mathematical calculations, and to study its exact and unalterable laws.

A ray of light is always a straight line while it remains in the same medium, or passes through another medium of the same density; but when it passes to a medium of different density, as from air to water or glass, its direction is at once changed. This is well illustrated by a simple experiment with which most people have amused themselves in childhood. Put a small coin in the bottom of an empty vessel, and place the eye in such a position that the coin is just concealed by the edge of the vessel; then let some

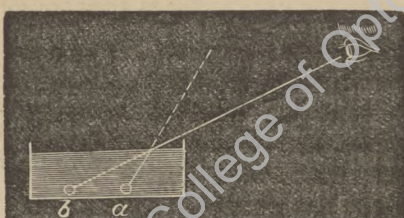


Fig. VI.—Refraction at Surface of Water Shown by "Coin Experiment."

one pour water into the vessel, and the coin will come into view. The rays of light coming from the coin, as they pass from the denser medium of water to the rarer medium of air, are bent, or *refracted,* at the

surface of the former, and take such a direction that it is possible for them to reach the eye. The object is seen in the direction in which the light reaches the eye, and the coin, situated at *a*, will appear to be at *b* (Fig. VI.). Refraction of light is the change of direction which its rays undergo in passing from one medium through another of different density.

The new direction of a refracted ray is determined by the density of the new medium and the form of its surface. A number of parallel rays, or *beam* of light, passing from the air through a piece of glass with parallel sides, have their general direction displaced, but emerge still parallel on the other side (Fig. VII.). If the surfaces of the glass are curved, and not parallel, the rays are either diverged or converged (Fig. VIII.). If, as in the case of the camera or the eye, the refracting surfaces are convex, the rays are brought together on the opposite side at a point called the *focus*. The focus of a common "burning-glass," in direct sunlight, is simply a minute image of the sun.

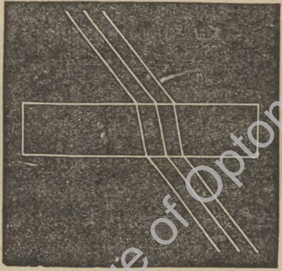


Fig. VII.

A bundle of divergent rays, or *pencil of light*, proceeds from every point on the surface of a visible

object, and each one of these pencils may be brought to a focus by a convex lens. The combination of the

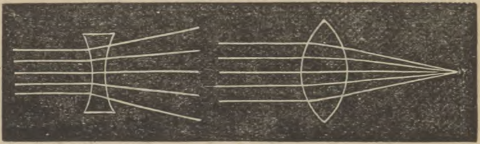


Fig. VIII.

focii of all the points on the surface of the object will optically reproduce the object, or form an *image* of it. Thus (in Fig. IX.) the pencil of rays proceeding from *a* are brought to a focus at *x*; those proceeding

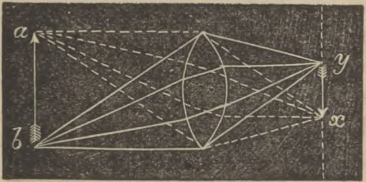


Fig. IX.—Formation of Image by Convex Lens.

from *b* at *y*, and those proceeding from every point between *a* and *b* at a corresponding point between *x* and *y*. In this way the picture is formed in a *camera*, which, in its simplest form, consists of a box with its inner surface blackened, a hole in the front in which a convex lens is placed, and a white surface on the back to receive the image that the lens forms of an object towards which it may be directed. In the eye, the sides of the box are represented by the

sclerotic, the blackened inner surface by the pigment of the choroid, the opening by the pupil, the convex

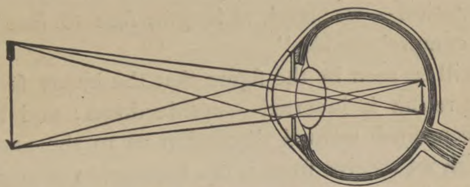


Fig. X.—Formation of Image on Retina. (*Whalley.*)

lens by the cornea and crystalline, and the surface to receive the image by the retina. Fig. X. illustrates the formation of an image by this living camera.

Thus far the act of vision is a strictly physical process; the rays of light can be traced to the image on the retina as definitely and accurately as they can be followed to the screen of the magic-lantern or the plate of the photographer's camera. But beyond this point we find ourselves in the misty region of theory and speculation, and the something that enables the image to excite a sensation, and converts the sensation into a mental process — that evolves thought and reason — like an ignis fatuus, eludes the grasp of science. Prof. Tyndall says that science not only does not explain it, but does not even tend to explain it, and that "when we endeavor to pass from the phenomena of physics to those of thought, we meet a

problem which transcends any conceivable expression of the powers we now possess. We may think of the subject again and again — it eludes all intellectual presentation — we stand, at length, face to face with the incomprehensible."

It will be seen by the figure that the image formed on the retina is inverted — upside down; and there has been much learned discussion as to the manner in which we receive from it the impression of an erect object. It must be remembered that, after all, it is the brain that sees, and that it sees not, strictly speaking, the external object, but what is called the "projection outward" of its image on the retina, just as we see the picture of the magic-lantern slide projected on the wall. Under favorable conditions, this projected image corresponds in position to the object itself, but those conditions are easily disturbed, when it becomes plain enough that we do not really see the object itself, but only, as it were, a phantom representation of it. If we look at an object through a prism, the rays of light coming from it are deflected, and, as the image is projected along the last direction of the rays, we see the object in a place where we know it is not, while the position actually occupied by it is blank. The sportsman who wishes to shoot a fish at the bottom of a pond does not aim at the phantom fish, but at the point where he knows the real fish must be. (See Fig. VI.) As the rays of light

are crossed in the eye, the inverted retinal picture is projected erect just as the inverted magic-lantern picture is, and for the same reason.

Vision is possible even without a retinal image, for an excited or disordered brain may project some phantasm of its own conjuring,—some "dagger of the mind,"—and see it as distinctly as if it were a tangible object; hence there have been many honest witnesses to impossible occurrences, whose falsehoods have been, not moral, but purely physiological.

All parts of the retina are not equally sensitive to visual impressions. The most sensitive portion is a small space directly in the line of vision, called the *yellow spot* from a yellow tinge seen in it after death. Indeed, this is the only portion of the retina that admits of distinct vision, and vision becomes gradually more and more obscure from this point towards the circumference. When we look at a large object or a landscape, we see only a small portion of it at a time distinctly, and "the image that we receive by the eye is like a picture, minutely finished in the centre, but only roughly sketched in at the borders." In reading, it is necessary to move the eyes backward and forward along the lines of the print, for without this movement we can distinguish not more than one long word. When we look at an object, we place the eye in such a position in reference to it that its image falls upon the yellow spot, and to obtain an accurate

idea of our surroundings, the eyes must be in continuous, though unconscious, motion. This necessity for frequent shifting of the line of vision has much to do with the expression of the face. A person of sprightly temperament and active mind wishes to "take in" all that is going on about him, and moves his eyes quickly from object to object to bring them all in rapid succession in the range of his yellow spot; while dull or phlegmatic people are satisfied with a general view of things, and do not take the trouble to focus them all in succession sharply on the most sensitive part of the retina.

It is a curious fact, that one spot on the retina, not very far from the most sensitive portion, is entirely insensitive to light, and, what at first sight may appear still more curious, this *blind spot* is at the entrance of the optic nerve, where the nerve fibres are most numerous, and where it might be thought that vision would be most acute. But the nerve fibres belong to the conducting layer of the retina, and the percipient layer, or Jacob's membrane, is, of course, wanting at the point where these fibres pass through it. The existence of this blind spot is very easily demonstrated by means of Fig. XI. Close the left eye, and direct the right to the small cross on the left hand side of the figure. Hold the page vertically before the eye, ten or twelve inches off, and then gradually bring it nearer, still keeping the gaze fixed

upon the cross: the round spot will also be visible, except at a certain distance from the eye, about seven

Fig. XI.

inches, when its image falls upon the entrance of the optic nerve, and it disappears from view. This is illustrated in Fig. XII.

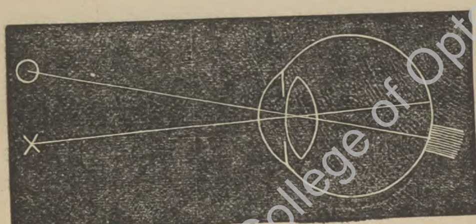


Fig. XII.—Blind Spot on Retina.

In tracing the rays of light to the retinal image, we have, so far, proceeded as if the rays from all objects required the same degree of refraction to focus them accurately on the retina. This is, however, the case only with distant objects, the rays from which come

to the eye practically parallel. All rays in Nature, whose course has not been interfered with, are divergent, but beyond a distance of fifteen or twenty feet the divergence is so slight as to be inappreciable, and they are considered as parallel. When the object is brought nearer to the eye, the rays from it are then practically divergent, and require to be more strongly refracted to bring them to a focus. (Fig. XIII.) This

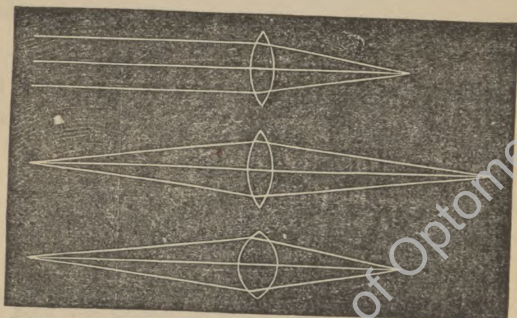


Fig. XIII. — **1. Focus of Parallel Rays. 2. Focus of Divergent Rays. 3. Focus of Divergent Rays brought forward by more Convex Lens.**

is a familiar fact in the use of any optical instrument, as an opera-glass; when directed from a distant to a near object, its focus must be adapted to the divergent rays by a mechanism provided for the purpose.

It is easy to prove that the eye forms no exception to this rule. If we hold a veil between our eyes and

a book, we can either read through it or see its meshes distinctly, but we cannot do both at the same time. While we read, the veil resolves itself into a kind of vague mist, and when we look sharply at the veil the print is no longer legible, but blurred and confused. When a fly is seen distinctly on a window-pane, the landscape beyond is obscure; and when the landscape is sharply defined, the fly becomes a shapeless spot. Such experiences show clearly enough that some change takes place in the eye to adapt it to different distances, and, indeed, Kepler long ago demonstrated that this was a mathematical necessity. Few physiological or mathematical problems have excited more interest or enlisted more talent than the determination of the nature of this change and the means by which it is accomplished. It is now known that the increased refraction by which the divergent rays from near objects are accurately focused on the retina is the result of an increase in the convexity of the lens. When we look at a near object the lens is rendered more convex by the action of the ciliary muscle — a small muscle in the interior of the eye, situated beyond the margin of the lens and connected with the delicate ligament that holds it in position. (Figs. I. and II.) Every act of near vision, therefore, is accompanied by muscular effort. The ciliary muscle does for the eye what the adjusting screw does for the opera-glass. The dotted lines in

Fig. XIV. show the increased curve in the lens in adjustment for near objects, and its effect in focusing the divergent rays. This faculty of adapting itself to various distances is called the *accommodation* of the eye, and is brought into requisition whenever there is the slightest change in the distance of any near object that we look at.

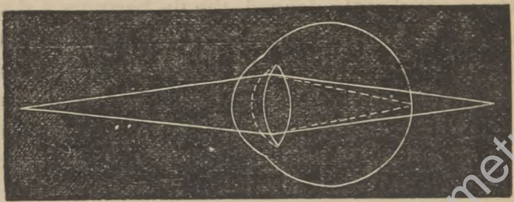


Fig. XIV. — Focus of Divergent Rays brought forward to Retina by increased Convexity of Lens.

The simultaneous use of both eyes is called "binocular vision," and to secure its correct and full effect, the eyes must have nearly the same acuteness of vision and degree of refraction, and the action of the external muscles must be so balanced that both eyes may be properly directed to the same object. There are, of course, two images formed of every object that we look at, one on each retina, and they are so combined by the brain as to give the impression of one object only when they fall on what are called "corresponding parts" of the two retinæ. Taking the yellow spot for the central point, the

corresponding portions are those above in each eye or below in each, or on the inner side of one retina and the outer side of the other — that is the portions that would come in apposition if one retina were placed upon the other. The most perfect binocular vision is when both images are on the yellow spots, but there is not double vision unless the images fall on other than corresponding parts, when they are immediately perceived separately, and two objects appear.

This is easily shown by pressing one eye slightly out of position with the finger, when everything will be seen double. Or hold two pencils in a direct line before the eyes, six or eight inches apart, and fix the eyes on the nearer one; the other will appear double because its image falls upon portions of the two retinæ that do not correspond.

The principal advantages of binocular vision are in the appreciation of the solidity (the "three dimensions") of objects, and in the accurate determination of distances. When we look at a solid object (with both eyes), the images formed on the two retinæ are not precisely alike; that in the right eye includes more of the right side of the object, and that in the left eye of the left side, and the combination of these two images gives the "stereoscopic effect," or impression of relief. This effect is imitated by the stereoscope, in which we have two slightly different pic-

tures of an object, one taken from the right side and the other from the left, and are enabled to combine them by means of prisms. The effect is even exaggerated by making the distance between the cameras, when the photographs are taken, greater than that between the eyes, which makes the difference between the pictures more decided.

We are greatly assisted in the estimation of distances by the simultaneous use of both eyes, for each eye gives accurately the *direction* of the object; and we know that its position must be at the intersection of these lines of direction. Persons who have lost one eye are much inconvenienced by the want of this assistance, as may be appreciated by attempting to thread a needle, or to touch a spot on paper with the point of a pencil quickly, with one eye closed.

In looking at an object closely, the eyes are turned towards it, or *converged*, by the action of the internal straight muscles — another muscular effort involved in near vision, which is far from being the merely passive sensation that it is too often considered.

The correct interpretation of the impressions received by sight is after all, to a great extent, a matter of practice and education, with the assistance of the sense of touch. This is proved by numerous observations made upon persons who have been born blind, and whose sight has been restored, or rather acquired, by surgical operation. None of these persons have

shown any indication of an instinctive use of their new-found sense; all have had to learn to see. None could distinguish form or distance, or could recognize at first, by sight alone, even objects that had been familiar to touch for years. Some seemed to find their first experiences painful rather than pleasant; and it is related of one, who had earned his living as a street musician and had gone about the town alone for years, that he became confused and lost himself when his eyes were opened, and had to beg some one to lead him home. All this is well illustrated in the interesting and instructive, even if somewhat apocryphal, story of Caspar Hauser, who was imprisoned in a dark cell for the first sixteen years of his life.

CHAPTER IV.

THE OPHTHALMOSCOPE.

WHY *does the pupil appear black?*" may seem like a very simple question, but thereby hangs the story of one of the most important discoveries of the 19th century. In the beginning of the last century, a French physiologist, while holding a cat under water in the performance of some experiment, was surprised by seeing the blood-vessels of the retina. As the aqueous humor behind the cornea is nearly pure water, its refraction was neutralized by the flat surface of the water in front of the cornea, and this caused the rays of light reflected from the bottom of the cat's eye to pass out of the pupil divergently, and thus rendered visible the structures from which they proceeded.

Though not understood at the time, this incident proved that the interior of the eye was not necessarily, under all conditions, invisible, and gave the first hint of brilliant possibilities, whose promise future developments more than fulfilled. The possibility of so modifying the optical conditions as to render the interior

of the eye visible, having once been demonstrated, the problem enlisted many distinguished scientists in its elucidation, and their efforts culminated in the invention of the Ophthalmoscope by Helmholtz, in 1851.

When we speak of seeing anything, we mean that rays of light proceeding from it reach our retina, and the pupil ordinarily appears black, because the eye of the observer is not placed in a position to receive the rays of light coming from the interior of the observed eye. If, for instance, we hold a candle in front of an eye to illuminate the pupil, the light thrown back from the bottom of the eye through the pupil, and towards us, will be intercepted by the flame; and, of course, we cannot place our own eye in the course of the rays, between the flame and the observed eye, without shutting off the light altogether. In either case, the pupil of the eye examined will appear black, simply because no light passing out through it can reach our retina. This part of the problem is solved by using, instead of the candle, a small mirror, usually concave, with a hole in the centre. Light is thrown by the mirror through the pupil, and the observer, by placing his own eye behind the central opening, has it directly in the line of the rays reflected from the interior of the eye examined, a bright red reflection from the blood in the vessels of the choroid immediately takes the place of the usual blackness of the pupil.

Having managed to light up the interior of the eye, and to perceive the light reflected from it out through the pupil, it only remains to focus this light accurately on our own retina in order to see distinctly every object from which it comes. This is accomplished by means of small lenses, of different focal distances, placed immediately behind the opening in the mirror. This forms, substantially, the ophthalmoscope now in general use, which gives a distinct and magnified view of the interior of the eye, and reveals to actual inspection many diseased conditions which were formerly the subjects of theoretical speculations. The lenses also afford the means of measuring the focus of the eye examined.

The uses of the ophthalmoscope are not confined to ophthalmic surgery, but physiologists have availed themselves of its aid to study the circulation in the only blood-vessels in which it can be seen during life, and general diseases are often detected by the changes that they make in the appearance of the retina and optic nerve. This is particularly true of diseases of the brain, for the ophthalmoscope enables us to inspect a large nerve within a short distance of its origin in the brain, and one that is wrapped in membranes and contains blood-vessels derived directly from those of the brain itself.

CHAPTER V.

INJURIES AND DISEASES OF THE EYE.

ONLY a brief reference will be made to some of the more common injuries and diseases of the eye, with a view to exposing their dangers and some popular errors in reference to them.

The guards with which the eye is provided to protect it from injury, have already been referred to, but, complete as they are, it is a matter of wonder that this extremely delicate organ, exposed as it is in numberless ways in its owner's constant pursuit of labor or pleasure, escapes so generally as it does. The most common form of injury is from particles of dust and small foreign bodies. As the course of the tears is from the gland at the upper and outer part of the ball towards the canals at its inner side, (Fig. IV.,) and as the lids are firmly attached to bone at their inner extremities, and only loosely to the soft tissues at their outer, such particles are usually washed by the flow of tears, and moved along by the action of the lids towards the space at the inner angle of the eye, which is called the "lacus lachrymalis," or tear

lake. From this we remove them, almost unconsciously, with the end of the finger, or perhaps the handkerchief. This little operation is performed very frequently of a windy day.

Occasionally, a cinder or piece of coal, or some other object with projecting points, becomes lodged on the conjunctiva, and, as everybody knows from experience, is the cause of most acute pain. A smooth object rarely gives much pain, and is almost invariably passed on by the tears and the action of the lids. This process may be assisted by gentle rubbing of the lids, which, however, only makes matters worse when the offending mote has once taken hold. This comparative harmlessness of a smooth body has suggested the popular notion of sending it after a lodged one, in the hope that it may displace it and send it on its way, which, it cannot be denied, is occasionally accomplished. Druggists sell, for this purpose, what are called *eye-stones*, which are supposed by some to have a mysterious kind of semi-intelligent action which enables them to search out and capture the intruder. The genuine article is the operculum, or lid, of a small shell found on the sea-shore; but when the stock of these is exhausted, some smooth seed, as a small bean or flaxseed, is sometimes substituted. A patient recently presented herself at the eye hospital with a highly inflamed and very painful eye, with which she had been suffering for weeks. When the

lid was everted, a germinating seed with quite a well developed sprout was found in the fold of the conjunctiva, where it had been liberally supplied with the requisites of warmth and moisture. The patient then remembered that she had placed her faith in an "eye-stone."

It is hardly necessary to warn intelligent readers against such mistakes as this, but it may be well to suggest that it is a very simple and easy thing to *evert the eyelid*, and that many hours of really serious suffering may often be saved by it, particularly in travelling. Direct the sufferer to look well downwards, then, taking the lashes of the upper lid between the finger and thumb, stretch the lid downwards and outwards, place the point of a pencil on the upper part of the lid, above the top of the ball, and press it downwards while the edge of the lid is raised. The inner surface of the lid is thus exposed, and the cinder can be readily removed by touching it with a fold of a handkerchief. When the mote is just within the margin of the lid, it may sometimes be removed by drawing the upper lid well down and pressing it against the skin of the lower lid.

When the foreign body has lodged on the firmer tissue of the cornea, its extraction is not so simple a matter, and rubbing only presses it in more firmly. The particle is usually driven with some force, as from a hammer or turning-lathe, but may be simply

blown into the eye, and imbedded in the cornea by pressing the lid against it. Often a minute piece of iron, that can scarcely be seen without a magnifying-glass, will give rise to great pain and intense inflammation. If it is completely imbedded, so as not to present any sharp point to scratch the lid in its movement over the cornea, the pain will be comparatively slight, but the resulting inflammation may still be severe. A foreign body should always be suspected, if a violent inflammation is lighted up suddenly without apparent cause, particularly if one eye only is affected. Of course, the only remedy is the removal of the offending particle, which should be accomplished without delay, but should not be intrusted to unskilful hands. Specks of iron and steel, however, may often be removed safely and promptly by the use of a strong magnet, which would be a useful thing to have at hand in establishments where workmen are liable to such accidents.

Wounds made with pointed instruments, such as scissors or fork, frequently penetrate the cornea and injure the lens, when a cataract is formed. This, in young people, is usually absorbed, but in adults may require an operation for its removal.

A not uncommon and a dangerous form of injury is that from *lime* splashed into the eye. Quick-lime acts as a powerful caustic, and often causes complete blindness by destroying the vitality of the cornea.

Even when the conjunctiva only is affected, the eye may be seriously disabled by a growing together of the raw surfaces of the lid and ball. The lime should, of course, be instantly washed out, as thoroughly as possible, with water, and any that may remain should be neutralized by bathing with a teaspoonful of vinegar in a glass of water, or rendered inert by sweet-oil. The latter is equally efficient and more soothing.

In case of injury by *acids*, one part of lime-water to three of water may be used, or the eye may be freely bathed in milk.

Sympathetic Ophthalmia.—When the eye is extensively lacerated by a wound, or when a foreign body is lodged in the ball, the effect is not always confined to the injured eye, but there is great danger of the other being lost by sympathetic inflammation. In nearly all such cases, the only safety from ultimate blindness is in the removal of the offending eye, which is no longer either useful or ornamental, but has become merely a dangerous deformity, and sooner or later, sometimes after many years, is pretty sure to give trouble. Fortunately, the operation for the removal of a disorganized eye is not a serious one, and the resulting disfigurement can, to a great extent, be concealed by the use of an artificial eye.

Fig. XV.
Artificial Eye.

Such perfection has been reached in the manufacture of artificial eyes, that close examination is often needed to distinguish them from the natural organ. They are thin shells, the edges of which fit into the folds of the conjunctiva, and they are held in place by the lids. One should never be worn more than two or three years, as, when the enamel is eroded by the tears and mucus, it loses the perfect smoothness of its surface and becomes a source of irritation.

Catarrhal Ophthalmia. — The most common disease of the eye is inflammation of the conjunctiva. Its simplest form is the catarrhal, in which the mucous membrane of the eye is affected in the same way as that of the throat and nose, and often at the same time. As the membrane is continuous with that of the nose and throat, its diseases may be so too, as in the case of influenza. It usually yields readily to rest and simple treatment, but if not checked, may run into the purulent form, or may become chronic and end in the condition known as *granular lids.* This latter is a very tedious and obstinate complaint, and is well known and much dreaded by patients who frequent hospitals and dispensaries. The inner surface of the lids becomes thickened and rough like sand-paper, and, by constant friction, impairs the transparency of the cornea. When the discharge in catarrhal ophthalmia consists only of an excessive secretion of tears and mucus, it is probably not contagious, but if pus is mingled with it, it may become

so at once, and in all cases it is prudent to take precautions against communicating the disease by allowing the smallest particle of the matter to come in contact with a healthy eye. It often prevails in an epidemic form in the spring, when frequent and extreme changes in temperature and prolonged dampness predispose to affections of the mucous membranes, and the eyes are irritated by wind and dust.

Purulent Ophthalmia differs from the preceding form principally in degree, and it is sometimes difficult to draw the line where one ends and the other begins. The discharge, which is thick and yellowish, and, in bad cases, very copious, is undoubtedly and virulently contagious. Whole families are sometimes inoculated by the discharge from the eyes of an infant who has had the disease so slightly as scarcely to attract attention. It is not common among adults who live in clean and roomy homes with comfortable surroundings, but is met with often enough in very young infants to be considered one of their special diseases. It is most frequent where a number of people are crowded together, as in barracks, asylums, charity-schools, etc. Some of the most frightful epidemics formerly occurred on slave-ships.

It is sometimes called *Egyptian ophthalmia*, from its great frequency in Egypt, where it prevails to such an extent as to assume the proportions of a national scourge, and the number and wretchedness of its vic-

tims sadden the journey of sympathetic travellers. Its causes are exposure to intense heat and glare, the high winds driving clouds of sand before them, and the poverty and ignorance of a large portion of the inhabitants.

Many soldiers of the Crusades were victims of this disease, and numbers of blind beggars groped about the streets of London and Paris, appealing to the sympathies of the passers-by with the cry of "Holy Land!" "Holy Land!" to show that they had lost their sight in the popular cause. Three hundred of these persons were cared for in an asylum established in Paris by Louis IX., which, from the number of its inmates, was called "Les Quinze Vingts." It is still in existence, with the same name, and is the oldest institution for the blind in the world.

Purulent ophthalmia is one of the most dangerous diseases to which the eye is subject, and its victims are the most numerous in asylums for the blind. Fortunately, in a large proportion of cases, it yields to proper treatment, particularly the form occurring in infants, which is nearly always curable in its earliest stages; but no time should be lost, as, in a bad case, a few hours sometimes decide the patient's fate. The most scrupulous cleanliness is always essential, and the greatest care must be taken that no towel or basin that the patient uses shall be used by any one else. When the disease appears in a building where

a number of persons are congregated, every one attacked should be immediately isolated, at whatever inconvenience.

The conjunctiva is nearly always inflamed in measles, and frequently in scarlet-fever and small-pox, and occasionally the diphtheretic membrane is formed upon it, either with or without an accompanying affection of the throat. There is danger in such cases that, in the overshadowing anxiety for the patient's life, the eyes may not receive due care and attention; but it should always be remembered how little of the pleasure and usefulness of life is saved if sight is lost.

The question is frequently asked whether it is better to bathe the eyes in cold or warm water. So far as external bathing is concerned, this is merely a question of comfort that may be decided by the experience of the individual; but it is not well to apply anything to the conjunctiva unless it is inflamed. Many people have an idea that it strengthens the eyes to open them under water, but, as we are not amphibious animals, though the eye may be able to bear this exposure to an unnatural element, it certainly cannot suffer for the want of it. Healthy eyes, if given anything like a fair chance, will take care of themselves, and need no attention beyond what may be necessary to avoid abusing them.

Diseases of the cornea may destroy or impair its transparency, or the ulcers that are frequently formed

may extend through its substance, allow the aqueous humor to escape, and involve the iris. Even when such ulcers heal most favorably, they leave a permanent scar in the form of a white speck. Inflammation of the cornea is usually painful and accompanied with distressing sensitiveness to light. It occurs most frequently in persons whose health has been subjected to some depressing cause, or in children who have inherited a delicate constitution. Many of the latter are subject to repeated attacks for years, but the tendency to their recurrence generally disappears before adult life, and if care be taken to prevent each attack from leaving a permanent mark, the eyes may finally remain sound and strong.

A large, white opacity of the cornea is often mistaken for cataract, and not many years ago, when a knowledge of diseases of the eye was not so general as now, this mistake was sometimes made by physicians, and such patients were sent hundreds of miles to have the cataract removed.

Iritis, or inflammation of the iris, often destroys sight by closing the pupil and shutting off the light from the interior of the eye. This very rarely happens if the disease is promptly and skilfully treated, but it is often masked by an accompanying inflammation of the conjunctiva; the patient, perhaps, thinks "it is only a cold," and neglects it until the mischief is done. It should always be suspected when, in an acute

affection of the eye, the sight is decidedly diminished and there is some pain in the ball, and particularly in the brow. The latter is always more severe at night.

Cataract is a disease of the crystalline lens. The lens becomes opaque, and obstructs the entrance of light so completely that, when the cataract is fully formed, the patient can merely distinguish light from darkness. The pupil loses its natural blackness and the whitish surface of the opaque lens is seen just behind it. Cataract is not "on the eye," as is popularly supposed, but in it. The mistake arises from confounding cataract with the whitish opacities of the cornea already referred to.

Treatment by any kind of medication is entirely useless; the only remedy is the removal of the lens by operation. Of course, in the absence of the lens, the light cannot be focused accurately upon the retina, and people who have undergone this operation have no distinct vision until a convex lens of glass is placed in front of the eye. As no artificial lens can imitate the power of the crystalline to accommodate its focus to different distances, two glasses are required, one for distance and one for reading.

Glaucoma is a disease in which an excess of the fluids of the eye makes the ball tense and hard, and exerts injurious pressure upon its delicate contents. In acute cases it is intensely painful, and rapidly destroys sight by pressure upon the nerve. In its earliest

stage, its progress can nearly always be checked by an operation which consists in cutting out a piece of the iris; but when the nerve is once paralyzed, the case is hopeless.

In no disease are early recognition and treatment more important, and many of its victims have been condemned to blindness by delay. No one with a violent pain in the eye and head, particularly if it is accompanied by flashes of light, rainbow colors, or dimness of vision, should allow himself to be lulled into a sense of security by calling it "neuralgia."

Diseases of the choroid and retina can be recognized only by the ophthalmoscope. When uncomplicated, they are painless, and may give rise to no other symptoms than dimness of vision — a symptom that, in all cases, is entitled to respectful consideration.

Amaurosis.— Before the invention of the ophthalmoscope enabled us to examine the interior of the eye, a number of unseen diseases were classified together under the general term of amaurosis, which was humorously, but not inaptly, described as a "disease in which the patient sees nothing and the physician sees nothing." Now, this vague term is rarely used, and only to indicate paralysis of the optic nerve or blindness resulting from disease of the brain. *Tobacco amaurosis* is a form of partial paralysis of the optic nerve met with in excessive smokers. Excessive use of alcoholic drinks is thought, by some authorities, to induce the same condition.

There is a popular notion that floating specks before the eye, or *muscæ volitantes*, are a symptom of "amaurosis," and they consequently very often occasion much unnecessary uneasiness, particularly to persons of nervous temperament. They have the form of small spots or circles, strings of beads, or gossimer threads, and float about in the field of vision. They are the shadows cast upon the retina by microscopic opacities in the vitreous humor, which do not usually attract attention, and are frequently met with in perfectly healthy eyes. "Muscæ" may be made evident in any eye by looking through a small pinhole in a card at a bright light covered by a ground glass globe. The dread excited by these specks, in the minds of people who devote themselves to watching them, sometimes almost amounts to monomania.

Color-blindness is the inability to distinguish certain colors. Base colors are those by the mingling of which, in proper proportions, we may produce any one of the other colors of the solar spectrum, or white, which is a combination of all of them. Red, yellow, and blue were formerly considered the base colors, but Thomas Young preferred red, green, and violet, and these have also been accepted by Helmholtz and others. This has reference to the mingling of colors by the retina, and not to the mixing of pigments. According to what is known as the

Young-Helmholtz theory, there are special retinal elements for each of these base colors; when all of them are simultaneously and equally excited, the sensation of white results, and the different colors are produced by the excitation of one or more of these elements in varying degrees.

A person completely color-blind for any one color is deficient in one set of elements, and his perception of other colors is affected just in the proportion that this one enters into their composition. The case may be complicated by partial color-blindness, and it must be confessed that there are many complications which are still subjects of discussion, and which prevent this theory from taking its place among those which may be considered as finally accepted.

A greater portion of the retina is naturally color-blind; in fact, perfect color-vision exists only in the central portion, around the "yellow spot." This may be readily proved by keeping the eye fixed, and passing some small red object, as a wafer, slowly across the field of vision. It will be found that the color fades away long before the form of the object becomes invisible. Green can be recognized beyond the limit for red, and the perception of blue extends beyond that of green.

The most common form of color-blindness is that in which red is deficient. It is frequently called

"Daltonism," because first carefully described by the great English chemist, Dalton, who was himself a subject of it. He was a strict Quaker, and when he was about to be presented at court, it was feared by his friends that it would be impossible to induce him to wear the scarlet robe, in which custom demanded that a doctor of civil law should appear. But it seemed to him like a harmless gray, and, finding it comfortable, he persisted for several days in wearing it about the streets of London, surmounted by a broad-brimmed hat, and with drab pantaloons peeping out beneath it.

Color-blindness is sometimes produced by disease, but usually exists at birth, and is often hereditary. It will be readily understood that in many occupations it is a serious disability, and, as the subject of it is frequently unconscious of the defect, the eyes should always be tested before such occupations are undertaken. Some otherwise excellent artists have been spoiled by it. It is a matter of grave importance in the case of seamen and of railroad engineers, and has lately attracted much attention in that connection all over the world. A green light at night marks the "starboard" or right-hand side of a vessel, and a red light the "port" side; while a red light on railroads is the signal for danger. A color-blind pilot or lookout has no means of knowing, on a stormy night, whether a vessel that he must pass is

steering to the right hand or to the left; and a locomotive engineer who cannot distinguish between red and green, does not know the difference between danger and safety to the hundreds of passengers whose lives are in his hands. The Swedish, Russian, and Bavarian governments have ordered all persons connected with railroads to be tested for color-blindness; in Italy, all railroad employés are subjected to rigorous examination; and investigations have been, or are being, made on an extensive scale in France, Belgium, Holland, Denmark, and Finland. In Finland, of 1200 employés examined, sixty were found color-blind. Not much progress has been made in England, though Prof. Tyndall has added his warning to that given strongly, twenty years ago, by Wilson; and little or nothing has as yet been done in this country.

This defect is much more frequent than is commonly supposed. Of a large number of men examined in Europe and this country, four or five per cent. have been found color-blind. Women enjoy, comparatively, a singular immunity. Drs. Cohn and Magnus found only one color-blind among 2318 school-girls tested in Breslau, and Dr. Jeffries found only two among nearly 2000 women and girls examined in Boston. No satisfactory explanation has been given of this fact, but it appears to be pretty well established, and, until a careful system of testing has been adopted, ladies who feel aggrieved that their

sphere of usefulness is too much restricted might well inscribe it on their banners in an advance, by land and sea, on every position where signal-lights are used.

As the crystalline lens grows dense with age, particularly if there is commencing cataract, a yellow tinge often takes the place of its natural colorless transparency. This must partially impair the perception of the complementary color, blue, to the extent, at least, of requiring a deeper tinge to produce a given effect. Liebreich, therefore, in his London lecture on Turner and Mulready, took the ground that the excessive blue in the later pictures of Mulready, who continued to paint after he was seventy years of age, was due to yellow degeneration of the crystalline lens, and maintained that this excess of blue could be neutralized, and these pictures could be restored to the harmony of the artist's earlier productions, by looking at them through a glass slightly tinted with yellow. Persons who have been operated upon for cataract sometimes complain, after the yellowish lens has been removed, that everything appears to them unnaturally blue. This effect soon passes off as the retina becomes accustomed to white light.

Among the causes of defective sight, *hereditary transmission* of optical defects, or of a tendency to particular forms of disease, is important.

It is met with in various forms. Color-blindness,

as has already been observed, is in a high degree hereditary. Prof. Wilson says, "it is a safe estimate, that every decided case of color-blindness implies the existence of another case of equal or similar severity in the person of a relative," and Dr. Pliny Earl, some years ago, gave the history of color-blindness in five generations of his own family.

Any anatomical or physiological peculiarity that has existed from birth (that is, "congenital"), is liable to be transmitted to the next generation, and persons blind from such causes would be liable to have blind children. The case is different, however, with acquired blindness, and many instances have been recorded of children with perfect eyes being born to blind parents. Four marriages of blind persons are known to the officers of the Pennsylvania Institution for the Blind; there were one or more children in each instance, and all had good sight but one, who was born quite blind, and this was the only case in which the blindness of either parent was congenital. Six of the inmates of this institution are the children of blind or partially blind parents.

The defects in focus, or optical defects, as will be explained in the next chapter, are dependent on the form of the eyeball, and are therefore very liable to be inherited. This is particularly the case with short-sight, the predisposition to which, at least, is considered by the best authorities to be in a large proportion of cases hereditary.

A peculiar affection ("Retinitis Pigmentosa"), which is recognized, with the ophthalmoscope, by the presence of black spots upon the retina, shows a very marked tendency to hereditary transmission. It also sometimes occurs in several members of a family, though its existence in a previous generation cannot be established. The prominent symptoms are "night-blindness" and a gradually increasing contraction of the field of vision. Its subjects may be able to go about alone well enough in daytime, but become helpless after sundown; and may see accurately with a small central space of the retina and be blind in other parts of it. Some authors set this affection down among the various evils let loose by the Pandora of consanguineous marriage, but, after much discussion, the most that can as yet be said of this view is that it is not proven. The proportion of cases that have been observed among the children of near relatives has not been large enough to exclude the possibility of mere coincidence.

A tendency to gouty or rheumatic iritis, to certain forms of inflammation of the optic nerve and retina, and to some forms of cataract, may be inherited, but perhaps is not so frequently as might be expected; while there are general diseases whose inherited taint manifests itself in the eyes of children, though the parent from whom it has been derived may have had no affection of the sight.

CHAPTER VI.

OPTICAL DEFECTS:

OLD-SIGHT, LONG-SIGHT, SHORT-SIGHT, ASTIGMATISM.

AS the eye is a camera, just as subject to the ordinary laws of light as any other optical instrument, it may be free from disease and perfectly sound, and vision may still be indistinct because the rays of light are not accurately focused upon the retina. The causes that give rise to such imperfections of sight are called optical defects.

Presbyopia, or *old-sight*, is the most common of these; in fact, unless neutralized by short-sight, it is, of a physical necessity, universal with all of us who live beyond middle age. People of fifty-five or upwards are frequently heard to boast that they can read perfectly well without glasses. Prof. Donders says of them, "such people consider themselves a lucky exception. They are extremely proud of their sharp sight. The inquiry whether they are near-sighted is answered in the negative, with a smile of self-complacency." But when their distant-sight is compared with the natural standard, it is invaria-

bly found to be deficient. The degree of the defect may be slight, and they may be unaware of it, but it necessarily exists. Old people who have been using glasses for twenty or thirty years, are sometimes surprised by a return of the ability to read without them, and this is spoken of as "second sight;" they have become short-sighted in consequence of a change that has taken place in the shape of the lens.

"Old-sight" is simply a partial loss of the power to accommodate the eye to different distances. A general explanation of this power of accommodation has been given, (Fig. XIV.,) from which it will be seen that the divergent rays of light coming from near objects are brought to a focus on the retina by increasing the convexity of the lens. Of course, this change in the form of the lens will be accomplished more readily in proportion as its substance is soft, and with greater difficulty when it is denser. Now, one of the most constant of the physiological changes that accompany advancing age is an increase in the density of the crystalline lens, and a corresponding diminution in the ability to change its form. Hence, the nearest point of distinct vision, which corresponds to the greatest convexity of the lens, year by year recedes from the eye. A child ten years of age can see small objects distinctly at two and a half or three inches from the eye; at about this time the change becomes manifest, and steadily advances until

the age is reached when we commence to "trombone our newspaper" in search of the receding near point of distinct vision, which at first becomes doubtful, and finally ceases, practically, to exist. "Far-sighted" is not a correct term for this condition; the far point of distinct vision is not altered, the near point is simply removed so far from the eye that small objects are no longer visible.

The first symptom of old-sight is a demand for brighter light and clearer print, and at length, somewhere between the ages of forty and fifty, dim light and poor print become so universal that we are forced to admit that our eyes are at fault, and to seek aid of the optician. The proper time to commence using glasses is when it is no longer possible to read with perfect comfort without them. A contest with age is hopeless, and it is the part of wisdom to yield gracefully to the first summons to surrender.

A convex glass is used to supplement the failing power to increase the convexity of the lens, and it is important that a proper glass should be selected. A common mistake of opticians is to commence with too strong a glass. People are apt to be pleased with such glasses, because by magnifying small print they make it unnaturally clear. It is by no means necessarily the case, though, that the glass that may seem most pleasant on first trial is the one that will give the most comfort in a long evening's work. The ob-

ject of the glass is not to magnify, this is merely an incidental effect, but to assist the lens in focusing divergent rays of light; only so much assistance as is really needed should be given, and anything more than this may be injurious. There is such a wide range of individual differences in the condition of the eyes, in nervous force, occupations, etc., that the attempt, sometimes made, to adapt glasses arbitrarily according to age is absurdly irrational. The same care should be exercised in increasing the power of the glasses as age advances; it should be done with reference, not to any stated intervals, but to the progressive failure of accommodation. It is well for persons who read or write a great deal by day and night to use the stronger glasses in artificial light only, and the old pair in daytime.

Hypermetropia, or *long-sight*, should not be confounded with the previous condition, as it very frequently is. This mistake is a natural one, as both conditions require convex glasses, and both are popularly called "far-sight," though this is not a correct term for either of them. Presbyopia, or "old-sight," as has already been explained, affects merely the near point of distinct vision, which is removed further from the eye; while in hypermetropia both the near and the far point are involved, and there is no distinct vision at any distance without a strain; this strain exists even for distant vision, but becomes

greater the nearer the object looked at. Old-sight is a failure of the power to accommodate the focus of the eye to near objects, resulting from a natural change, in the density of the lens; while hypermetropia is a defect in the focus, dependent upon the form of the eye, and exists in childhood. The term "far-sighted" is not a good one, because, though such eyes may see perfectly well at a distance, and much better than near by, they cannot see further than the perfectly formed (or "emmetropic") eye. The expression *long-sight* is sometimes used to denote the contrast with short-sight, which is the opposite condition in cause as well as in effect; in short-sight, the distance between the cornea and the retina is too great, and in hypermetropia it is not great enough.

It will be remembered that the perfectly formed eye, when in a state of rest, is adapted to parallel rays of light, which are therefore brought to a focus accurately upon the retina, where a distinct image of the external object, from which they come, is formed. Such an eye is called *emmetropic*, from the Greek word *emmetros*, according to measure, because the measure of its axis, or the distance between the cornea and the retina, is the same as that of its focal distance, or the distance between the cornea and the point where parallel rays are brought to a focus. If either the axis of the eyeball or the focal distance of the eye is too long or too short, if they do not ac-

curately correspond, the focus will not fall upon the retina, but in front of it or behind it, and this is what is meant by "an error of refraction." This is easily illustrated by holding a convex lens, or common magnifying-glass, in such a position in front of a piece of white paper that the image of some object, as a candle-flame or window-sash, will be formed upon the paper. When the outlines of the image are sharp and the picture is clear, the distance between the lens and the paper corresponds to the focal distance of the lens, just as in the emmetropic eye the distance between the cornea and the retina corresponds to the focal distance of the refracting surfaces of the eye. If the paper is moved ever so little, towards or away from the lens, the distance is no longer "according to measure," and the image becomes indistinct; precisely in the same way, the retinal image becomes indistinct if, from an imperfection in the form of the eyeball, the retina is too near or too far from the cornea.

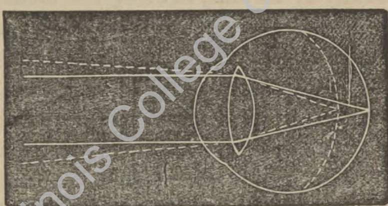


Fig. XVI.— Hypermetropia.

In hypermetropia (*hypermetros*, beyond the measure), the axis of the eyeball is too short, and the focus falls beyond the retina,

which is too near the cornea. If the shape of an emmetropic eye be compared to that of an orange, a hypermetropic eye will have more the form of a turnip. In Fig. XVI., the continuous outline shows the form of the emmetropic eye, and the dotted curve indicates the position of the retina in hypermetropia. It will be seen that rays of light which enter the eye parallel are intercepted by the retina, in this false position, before they are brought to a focus, and that only convergent rays can be focused accurately upon it. As all rays of light that have not passed through a convex lens are either divergent or parallel, and convergent rays are not met with in Nature, it would seem, at first sight, that an eye with too short an axis could have no distinct vision at any distance. This would be the case if it were not for the power of accommodation, which enables the eye, by increasing the convexity of its lens, to bring the focus forward on to the retina. (See Figs. XIII and XIV.) This, however, as has been explained, is accomplished by muscular action, and such an eye is subject to constant strain; even distant vision, which in the perfect eye is a passive sensation consistent with entire rest of the organ, requires an effort. In reading, the effort required, even by the natural eye, must be added to that already in use for distance, in the case of the hypermetropic eye, and the strain is proportionately increased.

In very young people, in whom the lens is soft and easily acted upon, and who usually occupy themselves less constantly in close work, a very considerable degree of hypermetropia may pass unnoticed; but sooner or later, according to the degree of the defect, the vigor of the individual, and the nature of his occupation, the time must come when the strain will manifest itself by discomfort, distress, or complete disability for anything but manual labor. At first there is merely a sense of fatigue on prolonged use of the eyes, with, perhaps, a slight pain or "heavy feeling" in the brow. Then, after reading for a time, particularly at night, the print, which at first may have been perfectly sharp and clear, becomes blurred and misty, or even fades away entirely; by closing the eyes for a little while, and, perhaps, rubbing or bathing them, it is possible to resume the strain, but the same experience is repeated. Persons who persist in struggling on in this way have, for some time after the work is laid aside, a feeling of fatigue and discomfort in the eyes, accompanied by headache, and not unfrequently dizziness, irritability, and mental confusion. Finally, in many cases, the tension of the accommodative power required for distant vision is felt, and these symptoms, to a greater or less extent, become continuous, even when no attempt is made to use the eyes for near work. The hopeless condition of such persons, before Donders

explained the true cause of their troubles, and reduced its treatment to a rational physical basis, may be judged from the following quotation from Mackenzie, the highest authority of the last generation: "In many cases, it is our duty to declare the disease incurable. If the patient is a young lad, bound apprentice to a sedentary trade, and the disease, from its duration and its mode of origin, not likely to yield to treatment, we may advise him to turn shopkeeper, to apply himself to country work, or to go to sea; if a female, occupied constantly in sewing, to engage in household affairs, or any other healthy, active employment. Many a poor man have I told to give up his sedentary trade, and drive a horse and cart; while to those in better circumstances and not far advanced in life, I have recommended emigration, telling them, that though they never could employ their eyes advantageously where much reading or writing was required, they might see sufficiently to follow the pastoral life of an Australian colonist." Now and then a child discovered by chance that he could study his lessons, or read his novel, comfortably through his grandmother's spectacles; but his mother snatched them from him as she would a loaded pistol or a cup of poison, and his family physician lectured him solemnly on the terrible risks he was running.

The obvious and certain remedy for all these

troubles — obvious enough, now that a master mind has pointed out the way to us — is to use the convex glass (Fig. VIII.) that will give to parallel rays of light the necessary degree of convergence before they enter the eye. The muscle of accommodation is thus relieved of its extra work, the focus is brought forward on to the retina, and the focal distance of the eye and the glass together is "according to measure."

Short-sight has for many years been called *myopia*, from two Greek words meaning to close the eye, because short-sighted persons have the habit of half-closing the lids in the effort to see distinctly; and this term has been retained by modern authors.

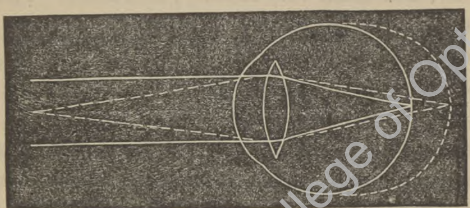


Fig. XVII. — Myopia.

While in the perfectly formed or emmetropic eye the focus for parallel rays of light falls accurately upon the retina, and in the hypermetropic eye falls beyond it, in myopia it falls in front of the retina. In hypermetropia the axis of the eyeball is shorter than the focal distance for parallel rays, and only conver-

gent rays can be brought to a focus upon the retina; in myopia the axis is too long, and no object can be seen distinctly until it is brought near enough to the eye to throw the focus of the rays of light coming from it back to the false position of the retina. In Fig. XVII., the continuous line shows the proper form of the eye, and the dotted line indicates the position of the retina in myopia.

It is thought that the tendency, at least, to short-sight exists, in most cases, at birth, and that it is, in a high degree, hereditary. It is possible, however, that it may sometimes originate in later life from abuse of the eyes, and there is no doubt that it is decidedly, and often very rapidly, increased. That it is extensively increased by close work, and is transmitted from parents to children through generations, is shown by its invariably greater prevalence among the classes that make most demand upon the eyes. It is one of the penalties of advancing civilization, and is met with more frequently in old communities than in new, in cities than in the country, in the professions and among students and literary people than among those who labor only with their hands. Its greatest prevalence is in Germany, where it has long been impossible to fill the ranks of the army without allowing soldiers to wear glasses. It is comparatively rare among seamen and farmers, and no one ever heard of a short-sighted Indian.

Even with the greatest care, there is nearly always more or less increase of myopia during the period of childhood and youth, when the organs are growing and the tissues are rapidly changing, and the results of imprudence and abuse are so disastrous that this is one of the most important problems that the reformers of the age have to deal with. The statistics upon this subject are really startling. Dr. Cohn, of Breslau, some twelve years ago, examined the eyes of more than 10,000 school-children, and found the percentage of short-sight increasing, from year to year, as shown by the following table:

Elementary school, . .	6.7 per cent.
Intermediate school, .	10.3 "
High school, . . .	19.7 "
Gymnasia, . . .	26.2 "

And in the high schools *one-half* of the first class were found to be short-sighted. Other examinations, since made in Europe and in this country, show the same tendency.

Because short-sighted people can see small objects with great distinctness, and may be able to read after middle age without glasses, there is a popular notion that short-sighted eyes are stronger than others. This is a dangerous delusion. Though myopia may remain stationary, and may be merely a matter of slight inconvenience, which is, to a great extent, compen-

sated for by the ability to read without glasses at the age when others are entirely dependent upon them, an eye with a high degree of short-sight is almost always an unsound one.

The essence of the defect is a bulging backward of the outer coat or sclerotic, which yields more readily as it becomes stretched and thin; and any excessive strain of the eye, anything that causes an increased flow of blood to the interior of the eyeball, adds to the pressure upon this weakened membrane, and forces it further back. The delicate choroid and retina, in attempting to follow the distended sclerotic, are seriously injured by the stretching. When the distension is very rapid and excessive, the retina sometimes becomes detached, and lies in loose folds in the disorganized vitreous humor, and there is an end to sight. This result may be considered exceptional, but it is not very infrequently met with, and should be borne in mind as a possible, though usually avoidable, termination of any case of rapidly progressive myopia. Inflammation of the choroid is also common in excessively short-sighted eyes, and large white spots, the result of wasting of this membrane, are frequently seen by the ophthalmoscope.

In short, myopia, when it exists in a high degree, is, in a large proportion of cases, a serious disease, which requires the most careful and skilful treatment.

Another common mistake is the belief that short-

sight diminishes with age. It will be remembered that old-sight affects only the near point of distinct vision, and not the far point; hence its effect upon a short-sighted eye will be to prevent it from seeing small objects so near as in youth, but not to make distant vision more distinct.

As a short-sighted eye is adapted only to divergent rays of light, it requires, for distant vision, the concave glass (Fig. VIII.), that will give to parallel rays the necessary degree of divergence. If, for instance, the farthest point of distinct vision is twelve inches, distant objects will be made distinct by a double concave glass of twelve inches focal distance; because such a glass gives to parallel rays of light coming from a distance the same degree of divergence that light has which comes from an object twelve inches from the eye. Persons beyond middle age, and sometimes younger persons, who are too short-sighted to read comfortably without glasses, require two pairs, one for distance and one for reading. The selection of glasses for short-sight requires great care, as much harm may be done by using those that are too strong or that are not properly fitted to the eye. In many cases, the plan of "trying" the various glasses on the optician's counter — or, far worse, the peddler's box — is about as rational and safe as it would be, in case of sickness, to *try* the contents of the various bottles on the druggist's shelf without a prescription.

As long-sight and short-sight depend upon the length of the axis of the eyeball, and not upon the curve of the cornea, it is hardly necessary to denounce the absurd pretensions of quacks, who have professed to cure them by increasing the convexity of the cornea with a suction apparatus, or diminishing it by pressure.

Astigmatism is an optical condition of the eye in which, from a want of uniformity in the curvature of the cornea, different meridians have a different focus. The perfectly formed cornea is part of a sphere or globe, and has the same degree of convexity in all directions, and therefore the same focal distance for all meridians. The astigmatic cornea is not symmetrical, but has different curvatures in directions at right angles to each other. Rays of light passing through the greatest curvature have the shortest focal distance, and those passing through the least curvature have the longest focal distance; and no sharply defined image can be formed by such a cornea. As a rough illustration, draw a line around an egg through the ends, and another around the middle, at right angles to the first; it will be evident that these lines have a very different curvature, and that if the egg were made of glass it could not form a sharp focus, as a glass sphere does — it would be astigmatic. Thus an astigmatic eye may be able to focus sharply either perpendicular or horizontal lines, but it cannot focus them both at

the same time, or with the same accommodative effort at a given distance. One meridian may be correct and the other myopic or hypermetropic, which is *simple astigmatism;* they may have different degrees of myopia or hypermetropia—*compound astigmatism;* or one meridian may be myopic and the other hypermetropic — *mixed astigmatism.*

The statement that the natural cornea is a section of a perfect sphere requires some modification, as, in point of fact, such a cornea is never met with. More or less astigmatism always exists; but, in the typical eye, the degree is so slight that it gives no inconvenience, and it can be detected only by delicate tests. If Figure XVIII. (one of Dr. John Green's test diagrams) be brought gradually towards the eye, it will be found that one set of lines remains distinct after those at right angles to it become blurred. Usually, the horizontal lines can be seen closer to the eye than the vertical; at the ordinary reading distance, however, they should all appear alike.

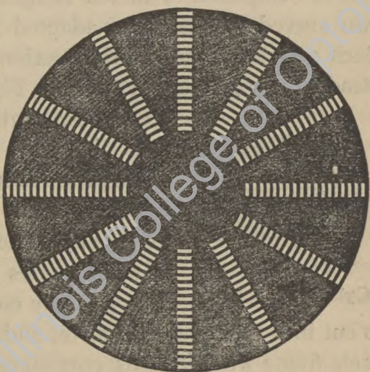


Fig. XVIII. — Test for Astigmatism.

Astigmatic persons, in reading, require different degrees of focusing for the horizontal and the vertical lines of the letters, and the distress that results from this continued and irregular strain of the muscle of accommodation may be readily understood. They usually attribute their defective vision to short-sight, but are disappointed in their efforts to correct it by short-sighted glasses, or by any glasses to be found in the stores. The surfaces of these glasses are spherical, and if they correct one meridian of an astigmatic eye, they cannot correct the other, but may make it worse. What is needed, in simple astigmatism, is a glass that will correct one meridian without affecting the other; and in compound or mixed astigmatism, a glass with two curved surfaces, one adapted to each meridian. Such a glass is found in the section of a cylinder instead of the section of a sphere. Fig. XIX. represents a cylindrical glass, and it will be seen that rays of light passing through its axis, *a b*, meet with no curve, and are therefore not refracted; while in the direction at right angles to the axis, *c d*, it is strongly convex. This glass is cut into the usual oval form, and is set in the spectacle-frame with its axis corresponding to the direction of the correct curvature of the cornea. In this way we are able to place the proper convex or con-

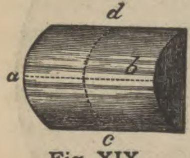


Fig. XIX.
Cylindrical Lens.

cave lens before one meridian of the cornea, and, at the same time, only a plain glass before the opposite meridian; or, if necessary, to correct each meridian separately by the appropriate curvature on each side of the glass.

A *difference* of focus in the eyes of the same person is not uncommon. One eye may be correct, and the other long-sighted or short-sighted; they may have different degrees of the same defect, or one eye may be long-sighted and the other short-sighted. Sometimes, when the difference is very great, it is convenient to wear glasses that will adapt one eye to distant vision and the other to near.

Irregular action of the external muscles of the eye-ball is closely connected with the subject of this chapter, as it is usually dependent upon optical defects.

When we look at a distant object, supposing the eyes to be optically correct, the axes of the eyes are parallel, and the muscle of accommodation is at rest — the image is formed upon the retina, in accordance with the physical laws of optics, without the necessity for muscular action, and vision is without effort. When, now, we look at some small object near at hand, both eyes must be directed towards it (their axes converged) by the action of the muscles that move the ball, at the same time that the focus is correspondingly altered by the action of the muscle of accommodation, increasing the convexity of the lens.

Here, then, is a closely associated action of the muscles on the outside of the eye, and the muscle of accommodation within it, that adapts the focus to the divergent rays of light coming from a near object; and the comfort, ease, and safety with which the eyes may be used depends much upon the proper balance of these two forces. Their relation cannot be disturbed without more or less danger or inconvenience; and such disturbance is a fruitful source of discomfort in cases of optical defect.

In hypermetropia there is an excessive strain of the accommodation, out of proportion to the degree of convergence that is used; while in high degrees of short-sight an excessive convergence is demanded without any action of the muscle of accommodation, as the eye is already adapted to very near vision, and does not require an increase in the convexity of the lens.

Squint. — The strain of the accommodative power in hypermetropia is the cause, in a great majority of cases, of squint, or "cross-eye." The demand for excessive accommodation causes an excessive tendency to convergence, which ends in a permanent turning inward of one eye. This kind of squint usually commences in children three or four years of age, or older, at the time when they begin to occupy themselves with near objects, as toys and pictures, and to demand accurate vision. At first it occurs only when

the eyes are directed to some near object; then occasionally even when a distant object is looked at steadily or carefully, particularly if the child is not well, and is therefore less equal to the strain than usual; and, finally, one eye remains constantly turned in towards the nose. The origin of the squint is frequently referred to some attack of sickness, as measles, scarlet-fever, whooping-cough, or convulsions. This may be merely a question of coincidence, as these diseases occur very frequently at about the age when squint is developed; or they may act as exciting causes, by reducing the strength of the patient so that the eyes are less able to bear the strain; but the real cause is a defect in focus, due to the fact that the eye is not properly formed—is not "according to measure."

It will be remembered that when a want of harmony in the action of the external muscles of the eyeball causes the image to fall on parts of the retina that do not correspond, double vision at once results (see page 42). To avoid this annoyance, persons with squint learn to use only one eye, and the image on the retina of the other is said to be "suppressed." In consequence of this constant suppression, the vision of the squinting eye becomes greatly impaired, in fact, accurate vision is lost, though the eye remains perfectly healthy.

In the early or periodic stage, before it becomes

constant, this kind of squint may be cured by correcting the optical defect with proper glasses, which remove the cause by taking away the strain. Of course, there are obvious difficulties in the way of this treatment in the case of very young children. It is worth some trouble, however, to remove so great a deformity without an operation, and, at the same time, to preserve the sight of both eyes, which is rarely, if ever, done by even the most successful operation, after the defect has been for some time established. After the squint has been cured by an operation, there is danger of its return unless glasses are worn.

In high degrees of short-sight, there is an excessive demand made upon the muscles that move the eyes inward (converge them), in the effort to keep them both fixed upon small objects held close to the face. Sometimes they prove unequal to this strain and give out, and one eye is turned outward by the opposing muscle, forming an external squint.

The constant strain involved in the effort to overcome this tendency to external squint is prominent among the causes that increase short-sight, and when it cannot be relieved by suitable glasses, an operation is sometimes necessary. This "insufficiency," as it is called, of the muscles that move the eyeball to do the work demanded of them, sometimes exists without short-sight.

These are the principal, but not the only, causes of squint. A squint occurring suddenly, with double vision, is generally the result of paralysis of one of the external muscles of the eyeball, and is frequently the first symptom of serious disease of the brain. Such a case should receive immediate medical attention.

Weakness of the accommodation (or focusing power of the eye), giving rise to symptoms much the same as those of old-sight, but from a different cause, may occur in young persons with perfectly formed eyes. The act of accommodating the focus of the eye to near objects is accomplished by a muscle which is subject to local and general influences, like any other muscle of the body. In old-sight, this muscle is not necessarily weakened, but the lens becomes too dense to be impressed by it; in the cases now referred to, the muscle is at fault. After long illness, the muscle of accommodation shares the debility of the whole system, and the eyes are not fit for continuous close work any more than the legs are equal to a long walk. The use of the eyes should be moderate at first and gradually increased.

After *diphtheria*, there is often a *paralysis of this muscle*, which is shown by difficulty or impossibility of reading, though the patient may be able to see perfectly well at a distance. It usually gets well under judicious treatment, though sometimes not for

several months. In the meantime, if there is no other objection to reading, proper glasses may be used.

Spasm of the accommodation is also occasionally met with, usually in persons of nervous temperament or as a result of overstraining of the eye. The continuous action of the muscle of accommodation keeping the eye always focused for near objects, establishes a kind of artificial short-sight. Any short-sighted glass, even the weakest, does harm in such cases, as it gives sharpness of vision by stimulating the already overstrained muscle to increased action.

Asthenopia, or *weak sight*, is the term applied to that state of vision in which the eyes, though their appearance is entirely natural and distant vision may be perfect, are more or less incapacitated for close work; they are unable to bear the strain of continued application to near objects. Asthenopia may result from any of the optical defects that have just been described, but its most frequent causes are long-sight (hypermetropia) and astigmatism. The demand made upon the eyes is excessive, and they prove unequal to it.

The symptoms of this form of asthenopia have already been briefly noticed. It is important to remember that not only may those referred to the eyes be the least prominent, but the sufferer may not suspect his eyes at all, while the strain is manifesting itself by

headache, dizziness, nausea, or nervous irritability, to such an extent as to excite apprehensions of serious disease of the brain.

The possible results of asthenopia from short-sight, and consequent strain of the muscles that move the eyeball, are well illustrated by the following case, published in an English medical journal, five or six years ago, by Mr. Carter, a prominent ophthalmic surgeon of London. "The patient's father was a banker in a provincial town, and the son, who was an only child, had been intended to succeed to his father's business and social position. About eighteen months before I saw him, he was at Oxford, reading hard for honors, and with confident expectation of obtaining them. His work was suddenly interrupted by symptoms which compelled him to obtain medical advice, and which were attributed to some serious and alarming cerebral disturbance. He was directed to abandon his studies immediately, and not only to give up the idea of taking honors, but even to leave the university immediately, without aspiring to an ordinary degree. He returned home, and there the opinion given at Oxford was reiterated by his family attendant, and was confirmed by a consulting practitioner in the locality. He was for some time under treatment, but derived no benefit, and at last came to London for further advice. An eminent physician, since deceased, concurred in the view that had

already been taken of the case, and pronounced absolute rest of brain to be essential to the patient's recovery. In order to obtain this rest, he was directed to undertake a voyage to Australia and back, and this direction he literally fulfilled. He went to Australia, made some brief stay there, and returned to England unimproved. He was then told that little or nothing more could be done for him; that he must abandon the idea of carrying on the family business, or of taking any active part in life; and that he must also abandon an engagement of marriage which he had formed prior to his illness. His prospects seemed utterly blighted, and he listened to his father's narrative with a careworn and dejected expression which was pitiable to see. The father concluded by saying that he had heard, from an unprofessional source, that oculists were in the habit of using some instrument by which they could see the state of the circulation in the brain, and that he had come to me in the forlorn hope that this instrument might throw some light upon the case.

"On inquiring into the actual condition, I was told that it was very 'peculiar.' The memory, the intelligence, the mental faculties generally, were all unimpaired, and at last I narrowed the case down to this—that the patient was unable to read. Before he had read a page, he became the subject of double vision, followed by vertigo; and also, if the effort

was continued, by sickness, palpitation of the heart, and intense headache. These were the symptoms that had interrupted his work at the University, and they had ever since recurred almost as soon as he opened a book. When he had not been trying to read, he was in all respects quite well.

"On examining his eyes, I found that they were both myopic in the same degree, and that the far point was only eight inches from the cornea. The patient had binocular vision, and had never worn spectacles. With concave lenses of eight inches focal length, the distant vision was nearly normal. Beyond myopic crescents, the ophthalmoscope showed nothing amiss.

"With these data, the condition of the case began to be manifest. The patient had never been able to read from a book which was more than eight inches from his eyes, and had generally held it still nearer, say at seven inches. The internal recti muscles, therefore, were required to maintain convergence of the two optic axes to a point only seven inches distant. Up to a certain period they fulfilled this requirement, but they broke down under a stress of work which was imposed upon them by reading for honors. The muscles became tired, they relaxed suddenly, and, as a matter of course, the two eyes being no longer directed to the same point of the page, the lines and characters would appear doubled. It is

probable that the whole system was somewhat overwrought; but the transitions from double vision to vertigo, from vertigo to faintness, sickness, and palpitation, and from palpitation to headache, are easily intelligible. The muscles, having once struck work, rebelled against even a short period of convergence; and the grave view taken of the symptoms by medical authority added anxiety and emotional excitement to the pre-existing elements of the case.

"My prescription was very simple. I explained the view I took of the case, and told the patient he had nothing whatever the matter with him. I ordered two pairs of spectacles, one of eight-inch concaves, — to be worn from morning to night, except when reading,— and one of fourteen-inch concaves, for reading only. The book was never to come nearer than eighteen inches, and the patient was to read three half hours a day, at three different times, and to come and report himself in three weeks. He and his father listened to me with polite incredulity, but they probably thought the advice worth trying, and they procured the spectacles. On that day three weeks the young gentleman returned alone, his spectacles on his nose, his front erect, his whole figure expanded, his countenance beaming. He said: 'I have come to see you again because you told me to do so, but I have nothing to say except that I am quite well; I am going to be married next week, and

to set to work at the bank as soon as we return from the wedding tour.' "

Asthenopia sometimes exists without optical defect, in cases of disturbance of the general health, particularly of a nervous character. The external muscles of the eyeball or the muscle of accommodation act insufficiently, painfully, or irregularly; or the sensibility of the retina is easily exhausted, and any object looked at fixedly seems soon to fade away. In some cases, though the eyes do their part perfectly well, the mere *mental effort* involved in reading brings on a headache or dizziness that makes it impossible to continue. This form of the affection, however, is exceptional, and should never be admitted until a careful examination of the eyes has excluded every possible physical cause.

The strain caused by optical defects is sometimes manifested only by an irritability of the eyes, or a slight chronic inflammation of the conjunctiva or lids.

CHAPTER VII.

SPECTACLES.

THE simplest forms of spectacles are those used merely to protect the eyes from mechanical injury or excessive light. Plain, clear glasses are useful in employments that expose the eye to injury from flying particles. In many cases ordinary window-glass answers perfectly well, or, if greater strength is required, plate-glass may be substituted. As the latter is uncomfortably heavy, it has been recommended to use thin, clear mica instead. If greater protection is needed than can be given by a glass curved like a watch-glass, the best material for sides is wire gauze, as it allows the air to circulate about the eyes, and does not heat them so much or shut them up in an atmosphere saturated with secretions. Protecting glasses are not worn nearly so much as they should be. With the natural disposition to underrate any danger that we are exposed to constantly, many workmen prefer the risk of going without the glasses to the inconvenience of wearing them, and often bear the scars of innumerable wounds of

the cornea. Generally, the only men who can be persuaded to wear protecting glasses are those who have already sacrificed one eye to their objections.

For protection against the glare of too bright a light, green glasses were formerly used; but as the orange rays of the spectrum are thought to be the most irritating to the retina, the complementary color, blue, is now preferred. There is a serious objection, however, to the long-continued use of any color in this way. The natural stimulus of the retina is white light, and glasses that decompose this leave the retina, when they are removed, unduly sensitive to the colors that have been excluded. The best glasses, in daylight at least, are the London smoke, or neutral gray, which, as nearly as possible, diminish uniformly all the light without separating its components. Those should be selected that are the most nearly neutral; some have a purplish tinge. Persons whose eyes are too sensitive to light find these glasses a great comfort at the sea-side; in fact, it is only by their aid that many people can enjoy the benefits of sea-air, and their use in this way is entirely unobjectionable. As a rule, they should never be worn in the house, and never at any time when not absolutely necessary, as, by accustoming the eye to a subdued light, they may increase the difficulty that they are intended to remove. Blue glasses are more in order at night, as artificial light, particularly gaslight, has an excess of

yellow, and is pleasantly modified by blue, which absorbs the yellow rays.

Cheap protecting spectacles are often made of poor glass, and contain flaws which produce an unpleasant distortion of objects seen through them. "Coquille," or shell-glasses (those shaped like a watch-glass), if their surfaces are not parallel, may act as weak lenses to a noticeable and even annoying degree. To determine if a professedly plain glass is free from refraction, hold it at some distance from the eye, and look through it at a window-sash across the room; when the glass is shaken from side to side, there should be no apparent motion of the sash.

Ladies often find the protection of a double veil more agreeable than that of any kind of glass, and, in the case of children, the broad brim of a straw hat, lined, if necessary, with dark silk or muslin, may answer perfectly well.

Weak convex or concave spectacle-lenses may be made of blue or gray glass, but when the lens has a strong curve, a difficulty is met with in the fact that its thick part is necessarily darker than the thin.

The sensitiveness of the retina is liable to be exhausted by long exposure to the dazzling reflection of sunlight from a wide expanse of snow. This is called *snow-blindness*. Alpine travellers who neglect to protect their eyes, sometimes suffer from it seriously. The Esquimaux guard against it by the

use of snow-spectacles formed of discs of wood with small holes perforated in the centres, which admit only so much light as is necessary for distinct vision. Though not very becoming, they are, perhaps, quite as efficient as anything that has been invented.

The spectacle-glasses in most general use are *double convex* for long-sight and old-sight, and *double concave* for short-sight. They have the same curve on each surface. (See p. 34, Fig. VIII.)

The *periscopic* glass is what opticians call a meniscus. One surface is convex and the other concave, and it has the effect of a convex or a concave glass, according as one or the other of these surfaces has the sharper curvature. (Fig. XX.) The advantage claimed for it is that the image is less distorted when the rays of light pass through it obliquely than is the case with the ordinary glass, and that, as there is less necessity for looking directly through its centre, the eye may move more freely behind it, and less turning of the head is required. There is no objection to its use, if it is found more convenient, but it has no optical advantage that can

Fig. XX.— A Positive and a Negative Meniscus.

compensate for its increased weight and additional expense.

Prismatic glasses are used for the relief of the external muscles of the eye. Fig. XXI. shows how it is possible to enable both eyes to see a near object

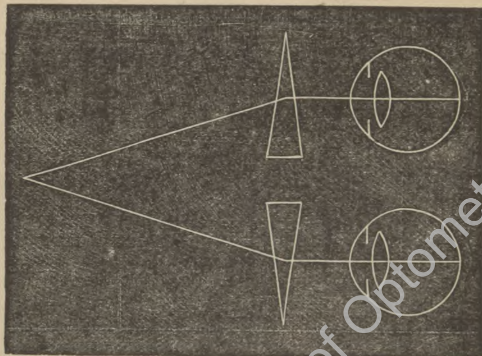


Fig. XXI.—Divergent Rays made Parallel by Prisms.

without converging. The prisms bend the rays of light towards their bases, and make divergent rays parallel. The degree of assistance given to the muscles in this way is regulated by the angle of the prisms. Prismatic glasses are sometimes used to correct double vision.

Cylindrical or astigmatic glasses have been described. (See Fig. XIX.)

Double focus glasses are sometimes used by persons

who need different glasses for reading and for distance. They are so arranged that the upper halves of the spectacles are adapted to distant, and the lower halves to near, vision; and they do away with the annoying necessity of frequently taking off one pair and putting on another. They are called Franklin glasses, because first used by Benjamin Franklin. He was slightly short-sighted, and therefore needed concave glasses for distance, and, as he grew older, also needed convex glasses to read with. He had too high an appreciation of the value of time to spend it unnecessarily in changing spectacles, and therefore cut a concave glass and a convex glass in half, and placing the concave halves above and the convex halves below, was always ready for either near or distant sight. Sometimes, instead of using "slit glasses," the two required curves are ground, one on the upper half and the other on the lower half of the same glass.

Spectacle lenses are usually made of crown- or flint-glass. The former is less expensive, but is softer and more easily scratched. Rock-crystal, or Brazilian quartz, is also used, and is commonly known as "pebble." It has no advantage over glass, except in hardness; in fact, the opticians find it difficult, or impossible, to distinguish between them without a polariscope or a file. Many people, however, are not satisfied unless they have "pebbles," or think

they have them, for glass is very often sold instead. What is essential in glasses is that they shall be perfectly clear, of uniform density, and free from flaws, and shall be properly ground with the right curvature. These essentials are by no means always to be found in cheap glasses, so that spectacles are not good things to economize in.

The kind of frame to be used is very much a matter of taste. It is important, though, that it should set properly, and that the glasses should be correctly centred, that is, that their centres should be opposite to the pupils. Sometimes, to produce certain effects, which it would be out of place to enter upon here, oculists order them decentred — the centres placed closer together, or farther apart, than the pupils.

Theoretically, the use of eye-glasses, as compared with spectacles, is not to be encouraged, but practically they will always be extensively used, and in most cases answer the purpose sufficiently well.

There is usually more or less resistance to be overcome in wearing glasses constantly. In over-sight and astigmatism, the strain of the muscle of accommodation, which has been established, perhaps, for many years, is not to be relaxed suddenly, or without persevering effort; while in short-sight, this muscle, which has never had any work to do, must learn to act. The change in the apparent size of objects, too, and in the estimate of distances is a source, at first,

of perplexity and annoyance. Sometimes, when the degree of the optical defect is high, its full correction can be reached only by gradual approaches — by means of a series of glasses increasing in strength.

In the case of any kind of optical defect, it is a great advantage to begin the use of glasses in youth, as the eyes adapt themselves to them much more readily then than in later years. The eyes and the glasses become, as it were, one optical instrument.

The fallacy of supposing that the glasses that are most pleasant for three minutes are necessarily the best to use for years, is not so general now as formerly. Experience has taught the public much in this respect: but there are still many people who would scorn to buy a ready-made suit of clothes, but who still do not hesitate, in the infinitely more important and delicate matter of selecting glasses, to make their purchases without a measurement.

CHAPTER VIII.

PRACTICAL SUGGESTIONS FOR THE CARE OF THE EYES.

ALL the organs of the body are better for moderate and rational use, and the eyes are no exception to this rule. Perfectly formed and healthy eyes should do their work without the consciousness of their owner; and the test of this condition is that there shall be nothing to remind us that we have eyes. This would be a safe measure of the amount and kind of work to be demanded of them, for there is, even in health, such a wide range of individual differences in vigor and endurance, that what is safe or moderate work for one person may be dangerous excess for another.

The great danger of people who have perfect and strong eyes, just as with those who have exceptional vigor of general health, is over-confidence. A French author, some years ago, wrote a book on "the advantages of a bad constitution," in which he endeavored, with much ingenuity, and not without some support from facts, to show that its tendency was to

prolong life, by banishing recklessness and promoting caution; and it cannot be denied that there are many people who would have had better sight in old age, if some slight weakness or defect had made them, in youth, more appreciative and careful of their eyes. It should never be forgotten that, while distant vision is a passive sensation not more exhausting than breathing, near vision demands convergence and accommodation, and therefore muscular effort. He who voluntarily forces a continuance of this effort until it is no longer possible to see, is scarcely more rational than the fools of the "walking match," whose ambition is to walk the greatest number of miles in the fewest number of hours that it may be possible to do and live.

It is well in reading to interrupt the strain of continuous gaze upon the page, and rest the eyes by looking into the distance occasionally, even if only for a few seconds. In studying, or in reading anything that requires thought, this is likely to be done unconsciously; the natural condition in close thought is rest of everything except the brain. Some of the biographers of Democritus assert that he put out his own eyes that he might devote himself more thoroughly to meditation, undisturbed by the impressions of sight.

One of the disadvantages of city life is the constant occupation of the eyes with close objects and

the absence of anything like a long, free range; those who are engaged in continuous and exacting city work experience an indescribable sense of rest when their eyes can be allowed to wander over a broad landscape or the boundless sea. A little fellow who had been taken to the country for the first time, on a Sunday-school picnic, pathetically illustrated this phase of city life, by exclaiming in raptures that "he never knew there was so much sky." He had seen only the little patch perpendicularly above the narrow court in which he lived, and whose pent-up limits comprised his world. He had never scanned the horizon, never seen a rainbow, or watched the flight of a distant bird — had never completely relaxed the tension of his eyes. It would be a wonder if, with a childhood alternating between this home and, perhaps, a crowded, ill-ventilated, and badly-lighted school-room, and a youth and manhood bound down to some close mechanical work, his eyes should be healthy and strong and well developed. Even the more prosperous dwellers in cities do not altogether escape this cramping tendency of town as compared to country, for nearly all their occupations, their business and pleasure, make a more or less constant demand upon the accommodative action of the eyes. It is their own fault, however, if this tension is not now and then relaxed; and not least among the advantages of a holiday trip is the freedom from strain,

the complete rest, that a distant range of vision gives the eyes.

As distant vision represents rest for the eyes, and near vision represents exertion, care should be taken, in reading, not unnecessarily to increase this exertion by holding the book too close. The book should not be held nearer to the eyes than is necessary to make the print appear perfectly sharp and distinct, and no print should be read continuously that can not be seen clearly at about eighteen inches. Short-sighted persons may, of course, read closer than others without straining the accommodation; and persons advanced in life, in whom the lens has become less transparent and the retina less sensitive, have to hold small objects closer to get the benefit of a larger angle of vision, and therefore a larger retinal image. In the case of the latter, however, there is no longer a question of this kind of strain, as the accommodation of the eye to near vision is accomplished by glasses, which also enlarge the visual angle and increase the apparent size of near objects. Without any optical or other discoverable reason, or, perhaps, merely in consequence of a careless and lounging way of sitting, young people often acquire the vicious habit of reading with the book held close to the eyes — a habit which, if examination of the eyes proves it to be nothing more, should be strictly discouraged. It is very important, however, to deter-

mine positively that there is no physical cause for the habit, and to remember that true short-sight depends upon the form of the eyeball, which no amount of discipline can alter. Great injustice is often done to children by accusing them of obstinacy or inattention, when they are the subjects of physical defects of sight or hearing. Those with a high degree of *long-sight* are particularly liable to be misunderstood, for, though they can see distant objects better than near ones, they sometimes hold the book close to the eyes to make the print appear larger, and thus partially compensate for their dimness of sight. In such cases, the retinal image, of course, becomes more indistinct the nearer the object is approached to the eye, but, as Prof. von Graefe showed by mathematical calculation, it gains more in size than it loses in sharpness of outline. Children with astigmatism often appear stupid or inattentive, because there is in this defect what the subjects of it sometimes aptly call "slow sight," that is, they do not recognize a word quickly on first sight, but "it seems to come to them afterwards." As has already been explained, the cause of this is that the perpendicular and the horizontal lines of the letters have a different focus, and a mental effort is required to combine them. When the sensitiveness of the retina becomes exhausted from fatigue or other cause, the impression of a larger

image is required, and the book is held closer to the eyes: it should be laid aside instead.

A very common way of straining the accommodative apparatus of the eye is by reading in a car or carriage. Between reading under these circumstances and reading in a motionless seat, there is all the difference between irregular and jerky muscular action and continued uniform muscular tension. A moderate and accustomed muscular tension, when once established, may be continued a long time without conscious effort or perceptible strain; but the case is very different with continually varied degrees of contraction. A weight that can be carried for miles without fatigue, may be found very exhausting if picked up and set down every few seconds for the same length of time. Ordinarily, when we take up a book to read, we adapt the focus of our eyes to a certain distance, and maintain a nearly uniform tension; but when we read in a car, the focus must be changed to suit every variation that the jarring makes in the distance between the eyes and the book. The external muscles, too, are strained in the effort to keep the eyes fixed upon the letters in their irregular movements. Business men who live out of town find a constant temptation to this imprudence in the morning and evening papers. Some people may be able to stand it without serious injury — just as some octogenarians will tell you that they have smoked all day

and a good part of the night for more than sixty years; but, on general principles, it is not a good thing to do.

Another equally, or perhaps more, injurious habit is that of reading while lying down. The extraordinary strain, in this case, falls, not upon the muscle that adapts the focus of the eye, but upon the external muscles of the eyeball that direct the eyes to the print. To direct both eyes to the same point requires a delicately balanced associated action of several muscles of each eye. In any part of the body, where a certain set of muscles are accustomed to act together in a given direction, this particular combination of movements becomes natural and easy, and any other comparatively difficult. This may be appreciated, for instance, by any one who has undertaken to drive a nail into the ceiling, and has experienced the fatigue of the muscles of the arm and neck and back that follows almost immediately. We are accustomed always, in converging the eyes towards any small object, at the same time to direct them downwards, as the object is usually held in the hand, or lies on something before us, below the level of the eyes. This facility of turning both eyes inwards and downwards at the same time has not only been acquired by the individual, but has been inherited from his ancestors, and has become a part of his nature; so that the association of convergence

with any other than a downward movement demands an extraordinary effort. This is a cause of fatigue in looking at pictures hung high in a gallery. Considerable interest has been excited recently by an affection noticed in miners, and called "miner's nystagmus," in which the external muscles of the eyeball seem to lose their balance, and the eyes continually oscillate. It is thought to result from the unnatural position of the eyes in working at the roof of the subterranean cavern in which these men pass their lives.

In reading while lying down, it is hardly possible to hold the book in a favorable position, and the external muscles of the eye are strained. In addition to this, when the head is on a level with the body, instead of erect, there is a tendency to an excess of blood in the eyes.

It is not well to persist in reading when overcome with sleep, as there is a constant tendency of the muscle of accommodation to relax, and of the eyes to diverge, and they have to be forced back to their work by an effort of the will. The effect of this is soon shown in a congestion of the blood-vessels of the conjunctiva.

As tension of the eyes in near vision is the principal cause of strain and fatigue, and the various diseased conditions that they bring about, common sense will dictate that the objects upon which near vision

is exercised should be such as not to make excessive or unnecessary demands upon this tension.

By far the most universal of these objects are printed letters; and as small print or poor print must be brought closer to the eyes to be distinctly recognized, it adds proportionately to the tension required, and is a fruitful source of injury. It is not easy to fix an arbitrary size for letters, as much depends upon their kind and form. The letters need to be larger if the strokes are fine, while heavier strokes may be easily recognized, if the print is clear, even in smaller letters. German letters are trying because of the extreme fineness of some of the lines that form them.

In reading, it is not usually necessary to see sharply all the details of the letters, as, if the characteristic parts are distinct, the rest is recognized, and the whole word is suggested rather than accurately seen. Letters may be readable without being distinctly visible. This is well illustrated by what are called **NORMAN CAPITALS,** in which the characteristic strokes are excessively heavy, and the others but lightly traced. The names of the streets in Paris are printed in this type, and can be read at a greater distance, and by a dimmer light, than would be possible with any other kind of letters of the same size. The space between the different parts of the letters, between adjoining letters, and between the lines, is also to be considered.

In the *test-types* used by oculists, letters seen at an angle of five minutes are adopted as the smallest that can be distinctly seen by the average eye. As the limbs and subdivisions of these letters measure one-fifth of their height, this gives an angle of one minute as the limit of accurate perception by the retina. According to this standard, the smallest letter recognizable at twenty feet would be about three-eighths of an inch in height, and at eighteen inches about one-thirty-second of an inch.

The following paragraph, from Dr. Snellen, of Utrecht, the author of the test-types in general use, gives a specimen of letters one-thirty-second of an inch in height:

"We have adopted as proper objects square letters, the limbs of which have a diameter equal to one-fifth of the letters' height. Such letters are clearly distinguished by a normal eye at an angle of five minutes. As the limbs and subdivisions of the letter just measure one-fifth of their height, they present themselves at an angle of one minute; for instance, our letter, C, shows an opening, as compared with the O, of one minute visual angle. In testing accuracy of vision, we accept perfect recognition, and not uncertain perception, of the letters."

As in ordinary letters the width of some of the strokes is much less than one-fifth of the height of the letter, a larger letter than this would be required for distinct vision. Of course, for continuous reading, the letters should be very much larger than those that it is just possible to see. Nor should type be made with reference only to perfect eyes and good daylight, as a vast amount of reading is done in artificial light and by imperfect eyes.

The quality of type is to be considered as well as the size, for print of fairly good size is often very trying to the eyes, because blurred and indistinct. The quality of the paper, and of the ink, too, has its influence on the general effect. Bright white paper, particularly if its surface is glazed, is dazzling and irritating. It is on account of the quality, rather than the size, of English print, that it is usually so much pleasanter to read than American. Some cheap publications manage to combine all of the defects referred to in such a degree that a more paternal government than ours might well suppress them as enemies to society. Fortunately, such publications do not contain intellectual treasures that it need tempt one to risk his eyes to reach.

As the eyes must be moved, in reading, to bring the image of each word in succession upon the yellow spot of the retina, if the page is very wide, the external muscles of the eyeball are fatigued by following the long lines, and it is better to divide such pages into *double column*.

The whole aim and object of the eye, with all its complicated anatomical, physiological, and optical apparatus, is to receive the impressions conveyed by *light;* and it is hardly necessary to urge the importance of considering the amount and kind and direction of the light in which and by which it must do its work. Though it is, of course, possible to use too

bright a light in reading, there is much more danger of the opposite extreme, and it is only necessary, in this direction, to avoid a dazzling or an irritating glare. It is not often that daylight indoors is too bright to read by — the direct rays of the sun being, of course, avoided — but too little light is a real and very common grievance. The distinctness of an object depends upon the amount of light reflected from its surface as well as upon its size; and to diminish the light by which it is seen is, so far as the eye is concerned, the same thing as to diminish its size. An increase in the size of the retinal image is at once required, to compensate for its dulness; to gain this increase, the object is brought closer to the eye, and the converging and focusing power is put upon the strain. Much injury is done by reading in twilight, and by reading or working in badly-lighted rooms. Good artificial light is much to be preferred to insufficient daylight.

The *direction* in which the light comes is by no means a matter to be disregarded. All light that does not come from the page, in reading, can only be a source of annoyance, by irritating the retina, if it is direct, or by confusing the image of the print with the images of other objects, if it is reflected. The irritating effect of direct light, even in distant vision, is shown by the pulpit-lights in church or the foot-lights in a theatre; and the confusion caused by

the interference of the images of other objects, may be illustrated by looking at a picture hung in the space between two windows, where it will be seen to great disadvantage, because its image on the retina has to contend with the images of the window-sashes, or of objects outside. We should therefore place ourselves in such a position that the direct light from the window will fall upon the book from above and from the side — preferably the left side, as, particularly in writing, a shadow is cast by the hand if the light comes from the right. The next best direction is, perhaps, from above; if from behind, a shadow is cast by the head and shoulders. The worst direction of all is that directly in front; indeed, this is so manifestly and immediately uncomfortable, that it is scarcely necessary to inveigh against it, as no one ever adopts it from choice. Light coming from below the level of the head is worse than useless, and, if the windows are low, it is often an improvement to darken the under sash. From an optical point of view, it is a mistake to place the shades at the top of the window instead of at the bottom.

The natural stimulus of the retina is white *sunlight*, and this is, of course, the best kind for the eye to work with. The softest and most pleasant of all light is the diffused light from a northern sky; but the point of the compass is not a matter of paramount importance, provided the light is sufficient in amount

and is free from annoying reflections. An excess may be easily regulated by shades, and is therefore the safest of all faults. The demands that the labors and pleasures of civilized life make upon the eyes, however, cannot be met by daylight alone, and during many hours of the twenty-four an artificial substitute must be found. The nearer an artificial light can be made to approach to the perfectly colorless daylight the better, but the most important requisites are that it shall be sufficiently bright and shall be steady — a flickering light is always bad. Gas-light has a decided excess of yellow rays, but is almost universally used in cities, and answers very well if the gas is of good quality and the flame is properly regulated. The flame of an ordinary "fish-tail" burner, exposed to every current of air, is never steady, and is unfit to read by. The shades or "globes" of a recent pattern, with wide openings at the bottom, have something of the effect of a chimney, and make the flame more steady. The Argand burner, with its shade and chimney, gives an excellent light and is easily controlled. The light of a good coal-oil lamp, particularly of that known as the "German student's lamp," is more grateful to the eye, and is used by many persons in preference to gas. A slight tinge of blue in the shade or chimney of a gas-flame modifies the light pleasantly by absorbing the excess of yellow rays.

We cannot think, without wonder, of the literary

work that our ancestors did by the light of tallow-candles or of "midnight oil," that we would think it a hardship to read by for an hour. Perhaps the retina accustomed to the glare of the nineteenth century needs a brighter light than theirs did.

The "coming" light is undoubtedly the electric. Among its many advantages is the fact that in color, or rather absence of color, it more nearly approaches daylight than any other. Its spectrum is nearly like that of sunlight. Though it has already been successfully applied to the lighting of large areas, its application to domestic purposes has so far proved impracticable, on account of difficulties in the way of dividing the electric current so as to produce a number of small lights instead of a single intense one of dazzling brilliancy; but, having made such wonderful strides of progress in the last three or four years, it is not going now to stand still always, even in the presence of the difficult problem of "divisibility." The restless and irresistible spirit of invention is hard at work, and has been heard from last in San Francisco, where it is proposed to illuminate a whole building, or even a street, by one lamp, the light from which is to be directed by lenses and reflectors, and to be conveyed by tubes, like gas or water, to as many points as may be desired.

The same general principles are to be observed in the care of *weak eyes* as of strong ones; but as the

penalty of excess or imprudence is more swift and sure, there is more urgent necessity for moderation and prudence. A great deal of work may often be done by weak eyes, if there is no actual disease, provided they are not urged beyond the limits of their endurance. The amount of work demanded of them should be proportioned to their strength. It should first of all be determined how much of their weakness may be due to optical causes, and how much relief may be derived from glasses; and they should then be given the benefit of greater care, more rest, more indulgence in distant vision, and more hours of sleep. Many eyes that are equal to all the rational demands of business, social, and domestic life, will inevitably break down if called upon to bear the strain of daily work, and also to pass the best part of the night in the glare and heat and dust, the close atmosphere, late hours, and excitement of the ball-room and theatre.

The principle of the familiar adage of "mens sana in corpore sano," is as applicable to the sight as to the mind, and a person whose whole system is debilitated should not expect full duty of his eyes.

CHAPTER IX.

EFFECTS OF SCHOOL-LIFE UPON THE SIGHT.

THE principles to be observed for the preservation of sight are, of course, the same in the case of children as of adults, and in school-work as in other occupations; but the greater necessity for carefully observing these principles at the time when the body, as well as the mind, is rapidly developing, and their very general neglect at this critical period, may justify a more detailed reference to them, even at the expense of some repetition. The increased demand that the exigencies or the fashion of the times make upon the eyes as well as upon the brains of children, and the increased numbers that are yearly brought within the influence of school-life by the compulsory laws of governments or of public opinion, should be accompanied by a corresponding increase in the use of all the alleviations and precautions that science and humanity can suggest. School-life is essentially an unnatural one; school-training is necessarily an artificial process, and unless it is conducted under rational and favorable conditions, universal education

can never be an unmixed universal blessing. M. Javal, of Paris, in a recent essay on the physiology of reading, says, "The necessity of reading with an increased assiduity, and at a more and more tender age, print whose fineness has been increasing from generation to generation, has resulted in generalizing myopia to such a degree, that if means of precaution are not taken this defect will end by affecting the whole human species."

The cramming for "exhibitions," and what Professor Huxley calls the "abomination of desolation" of competitive examinations, prizes, etc., that goad on children of various strength and capacity to tasks that the brightest and strongest are hardly equal to, are responsible for much injury of mind and body as well as of sight; and the "higher education," that is now so earnestly demanded for the gentler sex, is too often dearly bought at the expense of shattered constitutions and unstrung nerves. But if these things must be, in the name of humanity and justice, let them be surrounded by all the checks that can lessen their power for evil.

A matter of much importance, and one that is very generally neglected, is the air that children breathe in school. The carelessness or ignorance of public officials, or the narrowest possible considerations of economy, very often huddle an excessive number of children of the poorer class into small and ill-venti-

lated public schools; but this class are by no means the only sufferers, as the greater proportion of private schools are held in houses not intended for the purpose, and parents who give every care to the surroundings of their children at home, often seem strangely indifferent to the fact that they may spend many hours of the day, with twenty or thirty others, in a close and superheated little room that was built, perhaps, for five or six people to dine in. This is a fruitful source of income to the family physician, and now and then brings a case of weak sight, from debility and nervous exhaustion, to the office of the ophthalmic surgeon.

As the sense of sight is the chief medium of education, it is hardly possible to overestimate the importance of feeling assured that its organ is in proper working order, and that whatever defects Nature may have left in it have been, so far as possible, remedied by art. Though great advance has, of late years, been made in this direction, much still remains to be done, and many children, in the critical period of school-life, labor under disadvantages that a little care and attention might easily remove.

The case of children with long-sight is particularly liable to be misunderstood, because their stronger power of accommodation, — their greater ability to change the focus of the eye by increasing the convexity of the lens,— enables them to mask a degree of this

defect that would manifest itself in after-life by an absolute inability to read, or even by dimness of distant vision. It will be remembered that the axis of the long-sighted eye is too short (see page 73), and it has been explained how the optical defect of this malformation may be neutralized by a corresponding shortening of the focal distance — bringing the focus forward by increasing the convexity of the lens. What we are concerned with here, is the fact that in childhood the soft lens admits of a much higher degree of this change of form, and makes it possible to see, and to see distinctly, in spite of the defect. This, however, is accomplished by muscular strain, and demands a certain amount — sometimes a very considerable amount, depending upon the degree of the defect — of physical and mental effort. Such a child may be said to be "weighted" in the race with his classmates; he may be able, by virtue of superior strength or greater pluck, to keep up with the rest, or even to take the lead; or he may break down before the end of the race is reached. He seeks a bright light to get the sharpest possible image of the print, and may get on well enough in the morning, when he is fresh and vigorous, and light is abundant, but suffers most in the latter part of the day, when the light grows dim, and he is more or less fatigued. A bright light assists him, too, by contracting the pupil, and thus excluding the outer rays of the cone of light

which make the most confusion in the retinal image. He sometimes learns to increase this effect at night by holding the light between his eyes and the book.

A dislike of books sometimes originates in the extra effort required to read them, and an appearance of stupidity or inattention may have the same physical cause. Support is given to this view of the case, by the fact that the difficulty of distinct vision varies decidedly at different times, not so much with moral moods as with variations in mental and physical vigor.

As has already been explained, four-fifths of the cases of internal squint are the result of hypermetropia, or long-sight, and this great deformity, which is increased by use of the eyes, may generally be prevented, and sometimes cured, by proper and timely correction of the optical defect.

The eyes of children with this defect are usually "weak," and become watery and bloodshot after prolonged use. The edges of the lids are often thickened and red. Finally, the constant strain, excessive even for distant vision and painfully so for near, is a frequent cause of headache and other nervous symptoms.

In astigmatism the difficulties are still greater, and, in high grades, cannot be, even temporarily, entirely overcome. Even with the greatest amount of strain, vision is never quite distinct. Professional men of

middle age, who have all their lifetimes been at work with books without correction of this defect, are heard to say, when provided at last with cylindrical glasses, "this is the first time I have ever seen print distinctly."

Children with long-sight or astigmatism often struggle on for years under painful disadvantages, until finally they break down utterly, and an oculist is consulted to decide whether they had better give up school. Of course, they need glasses, and are old enough to wear them if they are old enough to study. They may not be becoming, but neither are headache, bloodshot eyes, wrinkled eyebrows, half-closed lids, or a squint — any or all of which may be the only alternative, so far as personal appearance is concerned, to say nothing of the importance of continuing their education with comfort and safety. Many people of a conservative turn of mind are greatly shocked at the degeneracy of the times, and the multiplicity and officiousness of eye-doctors, when they see a child with spectacles; ignoring the fact that such children, in the good old times when they themselves were young, were compelled to give up study altogether, or to struggle painfully and irregularly for a partial education.

As might have been expected from what has gone before, the most frequent of the injurious effects that follow tension of the eyes prolonged unduly, or under

unfavorable circumstances, is short-sight. The highest authority upon this subject, Prof. Donders, of Utrecht, says: "The distribution of near-sightedness, chiefly in the cultivated ranks, points directly to its principal cause — tension of the eyes for near objects. Respecting this fact, there can be no doubt.

"Three factors may here come under observation: 1st, pressure of the muscles upon the eyeball in strong convergence of the visual axes; 2d, increased pressure of the fluids, resulting from accumulation of blood in the eyes in the stooping position; 3d, congestive processes in the eye which, tending to softening, give rise to extension of the membranes. Now, in connection with the causes mentioned, the injurious effect of fine work is, by imperfect illumination, still more increased.

"To this it is to be ascribed that in schools where, by bad light, the pupils read bad print, or write with pale ink, the foundation of near-sightedness is mainly laid, which, in fact, is usually developed in these years."

These causes may not only increase to excess a slight degree of short-sight or develop an hereditary predisposition to the defect, but may produce it in an eye originally perfect. It has been positively established by careful and extensive statistics that short-sight is most frequently, if not almost exclusively, developed during school-life. This is due partly to

the fact that the eye during the period of its growth is more liable to change of form, and partly to the fact that children have a much stronger power of accommodation than adults, and therefore hold objects much closer to the eyes; but, to a great extent, it is due to preventable causes that are too often overlooked by parents and teachers.

The dangers to be avoided are: a too prolonged tension of the eyes, concentration of the sight upon objects too near, and straining of the external muscles of the eyeball by a position of the book or paper unfavorable to their free and natural movement.

It is important in all cases, and particularly if a tendency to short-sight is known to exist, not to urge or to allow children to keep the eyes fixed upon the book too long without intermission; this is not an imaginary danger, when a certain task is to be accomplished in a given time. No form of punishment that involves this kind of strain should ever be adopted.

The book or paper should never be closer to the eyes than ten or twelve inches, and if there is short-sight enough to prevent the letters from being distinct at this distance, it is usually better to wear proper glasses in studying. The print should, of course, be large enough and clear enough to be seen with ease at a much greater distance, and it is important that pale ink should not be used in writing. (See page 113.)

Reducing the size of print has much the same effect as diminishing the amount of light, as the smaller the print the more light necessary to make it distinct, and the closer it is brought to the eye. This is appreciated at the commencement of old-sight, when fine print can be read only in a bright light, because the loss of accommodating power prevents us from compensating for the smallness of the type by bringing it closer to the eyes. Children are able to do this, but they do it at the expense of a strain that may inflict permanent injury upon the eyes. Printers' type, particularly for school-books, is a bad thing to economize in.

The cause that most frequently necessitates a too near approach of the book is a defect in the amount or direction of the light. Dr. Cohn, whose statistics of the examination of more than ten thousand school children in Germany have already been referred to (see page 79), found that "the narrower the street in which the school was built, the higher the opposite buildings, and the lower the story occupied by the class, the greater was the number of near-sighted children;" he also found that, while in the village schools the proportion of near-sighted pupils was only 1.4 in a hundred, in the city schools it was 11.4 per cent.

It is impossible to establish any general and uniform measure for the proportionate size of windows, as so

much depends upon the point of the compass from which the light comes, and, particularly, upon the character and the proximity of surrounding buildings; but it should always be remembered that an excess of light is easily controlled, while a deficiency is an irremediable defect. Dr. Cohn, in a recent publication, maintains that a school-room cannot have too much light, and recommends the very large proportion of a square foot of window-glass for every square foot of floor, and says that less than about half this proportion should never in any case be allowed. Some other authorities consider the proportion of thirty to one hundred usually sufficient.

The direction of light is scarcely less important than the amount. Much discomfort may be caused by shadows thrown upon the book or paper by the shoulders, head, or hand, but the most injurious direction for light to come from is that directly in front. Such a light not only causes a close approach to the desk, by bending over to shade the eyes from the glare by the brow or perhaps by the hand, or turning of the head to one side, which brings one eye nearer to the work than the other, but the dazzling has a directly irritating effect upon the retina and conjunctiva. It is extremely annoying to the strongest eyes, and is intolerable to persons whose eyes are weak or unduly sensitive. There is rarely any excuse for this mistake, as it is nearly always possible to

place the desks or seats in such positions as to avoid it; but it is still not uncommon to see class-rooms or study-rooms, even in buildings erected especially for school purposes, in which the only comfortable and safe pair of eyes is the teacher's. The conditions to be observed are simple enough; the room should be oblong, and be lighted by high windows in one of the long sides, and the rows of desks should be parallel to the short sides, and should face so that the light may come from the left. A large, square room, with windows on two or more sides, can never be properly lighted.

In erecting a building for school purposes, it involves little or no additional expense to provide windows of sufficient size, and in utilizing a house built for other purposes it is usually possible to enlarge the windows, if necessary. The majority of school-houses are, at best, not models of architectural beauty; and, at any rate, this is a matter of secondary consideration where such grave practical interests are involved. Further, it should be remembered that "there is an architecture for schools as well as an architecture for palaces. One is not less worthy of study than the other, and we are at fault in taste as well as in hygiene if we forget that here real beauty consists, above all things, in the perfect adaptation of a building to its uses." In some Austrian and Swiss schools the plan has been adopted of fixing

shades at the bottom of the windows, so that they may be unrolled upwards instead of downwards. By this arrangement, when light is excessive, it can be modified by excluding the portion that is less useful and agreeable, and admitting only that which comes from above. Light striking below the top of the desk can reach it only by reflection, and is uncertain and confusing.

At night, a number of desks cannot be lighted to advantage by any one source of light, however brilliant. The same rule as to direction should, of course, be observed as in daytime. Liebreich recommends the use of reflectors, and suggests that they might be so arranged as to act, at the same time, as ventilators. The vitiation of the atmosphere by the combustion of a number of lamps or gas-jets is not to be lightly considered. Ground-glass globes are condemned by all authorities as unsuitable for school purposes. The very property that makes them useful for the general lighting up of a room, that of diffusion, unfits them for this use.

The size and form of the desk, and its relation to the seat, are not without their effect upon the welfare of the eyes. To use desks and seats of the same pattern and size for a large number of children of all ages, is not more rational than the system of distribution of army clothing, by which, as Dickens complained, all the tall soldiers got the short pantaloons,

and the short soldiers got the long ones. If a child is uncomfortably seated, he is pretty sure to lean forward on the desk, thus bringing his eyes too close to their work, and, at the same time, overfilling their blood-vessels by gravitation.

As the muscles of the back become fatigued by sitting long in a constrained position, the tendency is to bend over more and more, and this faulty position, at first assumed for temporary relief, becomes, by frequent repetition, a confirmed habit, and may end in permanent deformity. Thus a relation is established between short-sight and spinal curvature, and either may promote or increase the other.

Another affection of the eyes that may result from improper arrangements for study, is that known to ophthalmic surgeons as "muscular asthenopia," a disturbance of the harmonious action of the muscles that move the eyes and direct them both to the same point of the book or paper. (See page 110.) An excessive convergence to an object too close cannot be maintained without injurious strain, and a direction of the axes of vision upwards or sidewise demands an unnatural, and therefore fatiguing, combination of muscular actions. It will be readily understood how the positions often assumed by children at school must necessitate one or even all of these conditions.

According to Liebreich, the most common and important defects in school furniture are the following:

"1. Want of, or unsuitable, backs.

"2. Too great a distance between the seat and the desk.

"3. Disproportion, generally too great a distance, between the height of the seat and that of the desk.

"4. Wrong form and slope of the desk."

Illustrations of model desks and seats, proposed by Liebreich for remedying these defects, may be found in his lectures on school-life.*

"The back ought to be straight, and consist of a piece of wood only three inches broad. If this is fixed at a proper height, viz., close above the hips, it supports the loins sufficiently to make it easy and comfortable for even the most delicate children to sit perfectly upright. The seat ought to be broad enough to support almost the whole length of the thigh, and the height of the seat such as to allow the sole of the foot, in its natural position, to rest on a foot-board. The edge of the desk must be perpendicularly above that of the seat, and just high enough to allow the elbow to rest upon it, without displacing the shoulder."

A flat desk promotes a stooping position, with its attendant evils of close sight and gravitation of blood to the eyes, and, besides, does not permit the di-

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* The subject of "School Hygiene" will be treated in a future number of the Primers.

rection of vision most favorable to the natural and easy movement of the eyeballs. An inclination of forty or forty-five degrees is considered the best for reading, as, when the body is erect, and the eyes are directed downwards and forwards, this brings the page about at right angles with the line of vision. This slope would be too steep for writing, and an angle of about twenty degrees is recommended. The inclination of the desk may be changed by a very simple mechanism.

Still more serious considerations (which it would be out of place to discuss here) are involved in this question of the construction of desks and seats. A distinguished orthopœdic surgeon, Eulenberg, has stated that ninety per cent. of curvatures of the spine, not induced by local disease, are developed during school-life; and a number of high authorities have testified to the sad effects that crooked and stooping positions at school may have upon the heart and lungs and abdominal organs as well as upon the spine and the sight.

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THE END.

RULES AND REGULATIONS

No. 1. The library will be under the immediate control and supervision of the librarian, acting under the direction of the officers of the Physiological Section.

No. 2. Each person entitled to draw books from the library will be supplied with a card inscribed with his or her register number. This card must be returned whenever a book is taken, returned or renewed. Immediate notice of change of residence must be given to the librarian. Neglect to do this will subject the card holder to a forfeiture of privileges for books drawn by means of his card. To avoid responsibility for books drawn on cards by unauthorized persons, the registered holder should give immediate notice to the librarian of the loss of the card.

No. 3. No book can be retained by the person borrowing it more than forty-five (45) days: *provided always*, that any book may be borrowed twice by the same person, but not more than twice until it shall be returned to the librarian and have remained there at least one full month. Any borrower wishing to renew a book for the second time MUST send his or her library card so as to reach the librarian before the expiration of the first 45 days, otherwise he or she will be liable to pay a fine as stated in Rule No. 4. Any book detained two weeks beyond the time limited by these regulations shall be sent for by the librarian, and the borrower shall pay to the librarian the further sum of twenty-five cents to defray the expense of reclaiming such books.

No. 4. To protect the library against loss, and to secure to all a just and equitable share in its benefits, any person detaining a book longer than the regulations permit, shall thereby become chargable with the sum of five cents per day for each day, including Sundays, of such unauthorized detention.

No. 5. If any borrower lose or materially injure a book, paper or magazine belonging to the library, he shall furnish another copy of the same or later edition, or pay the librarian's appraisement, at the option of the librarian. If any book so lost or injured be a part of a set, he shall, at the option of the librarian, replace or pay for the entire set and may thereupon receive the remaining volumes as his property

No. 6. No books will be issued to parties who have any fines remaining unpaid, or to any member of the Section who is in arrears for dues.

No. 7. Borrowers will be furnished a list of such books, papers or magazines kept in the library, together with the postage rate on each book, paper or magazine, which amount, in postage, MUST be sent to the librarian, together with their library card, when applying for a book. Should they wish the book sent by registered mail, eight (8) cents additional must be sent. Members are kindly requested to lay postage stamps between sheets of *oiled* tissue paper to prevent the stamps from adhering. The express rate will be given when the book is too heavy for mailing, and the express rate must be sent in coin, not stamps. Books, papers or magazines will be sent at the borrower's risk.

No. 8. Any member of the Physiological Section wishing to use books in this library shall apply to the Secretary for a blank bond, which bond must be filled and attested to before two witnesses. The principal and surety must bind themselves jointly and severally to the sum of twenty-five ($25) to be paid to the librarian for the loss or damage of any book belonging to the library. No member will be furnished with a library card or permitted to draw books until such a bond has been furnished the officers of this Section and duly approved by the librarian or secretary.

No. 9. Books of rare historic value will be loaned only upon condition of additional security satisfactory to the officers of the Section.